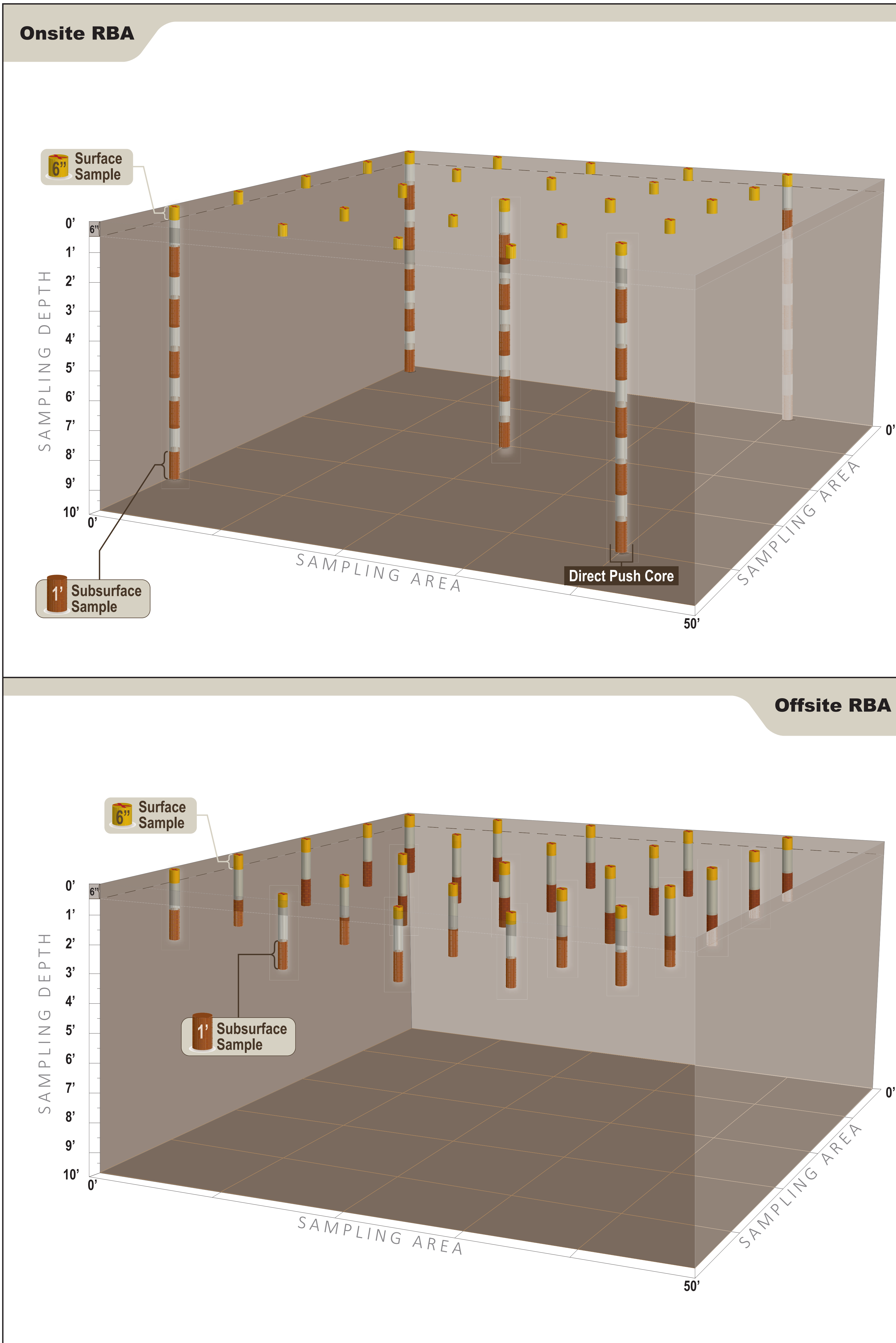
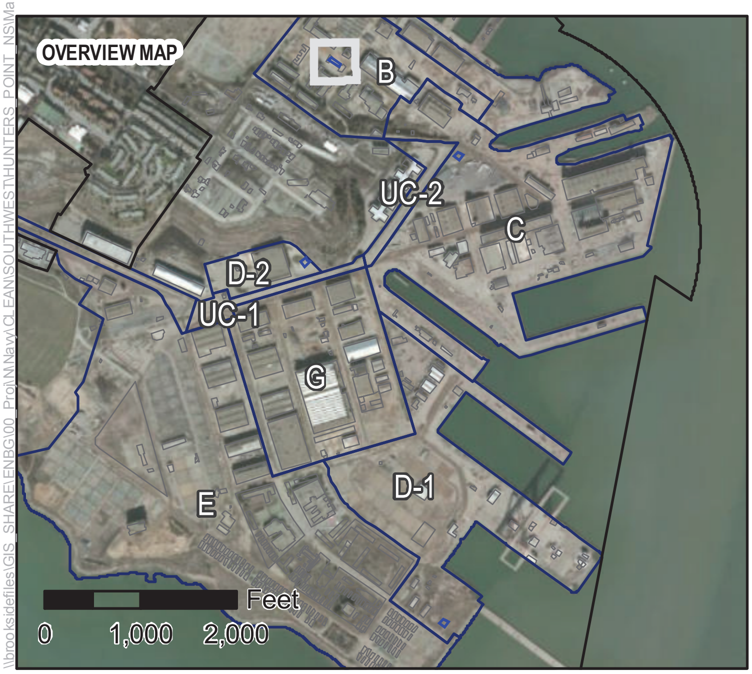


Figure 3-3
Example Surface and Subsurface Sample Locations
Soil Reference Background Area Work Plan
Former Hunters Point Naval Shipyard
San Francisco, CA



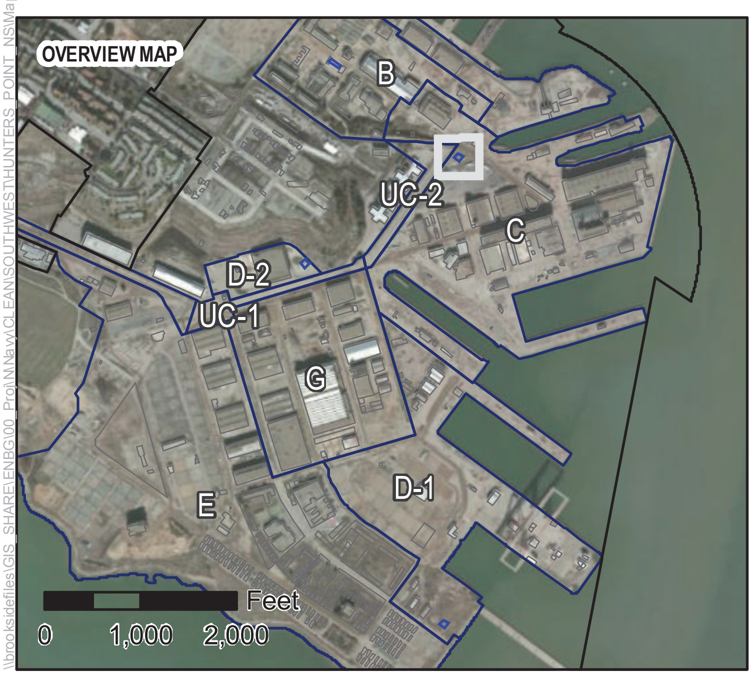
Legend:

- Surface Sample Location
- Surface and Subsurface Sample Location
- Reference Background Area
- Installation Boundary
- Parcel Boundary
- Current and Former Building Site

COORDINATE SYSTEM:
NAD 1983 StatePlane California III FIPS 0403 Feet

BASE MAP SOURCE:
Service Layer Credits: Source: Esri, DigitalGlobe, GeoEye, Earthstar Geographics, CNES/Airbus DS, USDA, USGS, AeroGRID, IGN, and the GIS User Community

Figure 3-4
HPNS Reference Background Area RBA-1
Soil Reference Background Area Work Plan
Former Hunters Point Naval Shipyard
San Francisco, California



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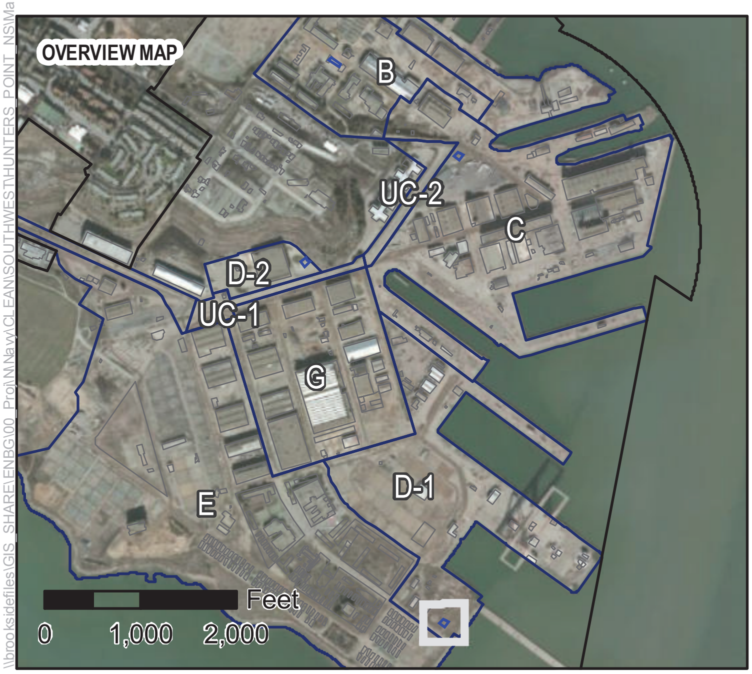
Legend:

- Surface Sample Location
- Surface and Subsurface Sample Location
- Reference Background Area
- Installation Boundary
- Parcel Boundary
- Current and Former Building Site

COORDINATE SYSTEM:
NAD 1983 StatePlane California III FIPS 0403 Feet

BASE MAP SOURCE:
Service Layer Credits: Source: Esri, DigitalGlobe, GeoEye, Earthstar Geographics, CNES/Airbus DS, USDA, USGS, AeroGRID, IGN, and the GIS User Community

Figure 3-5
HPNS Reference Background Area RBA-2
Soil Reference Background Area Work Plan
Former Hunters Point Naval Shipyard
San Francisco, California



Legend:

- Surface Sample Location
- Surface and Subsurface Sample Location
- Reference Background Area
- Installation Boundary
- Parcel Boundary
- Current and Former Building Site

COORDINATE SYSTEM:
NAD 1983 StatePlane California III FIPS 0403 Feet

BASE MAP SOURCE:
Service Layer Credits: Source: Esri, DigitalGlobe, GeoEye, Earthstar Geographics, CNES/Airbus DS, USDA, USGS, AeroGRID, IGN, and the GIS User Community

Figure 3-6
HPNS Reference Background Area RBA-3
Soil Reference Background Area Work Plan
Former Hunters Point Naval Shipyard
San Francisco, California

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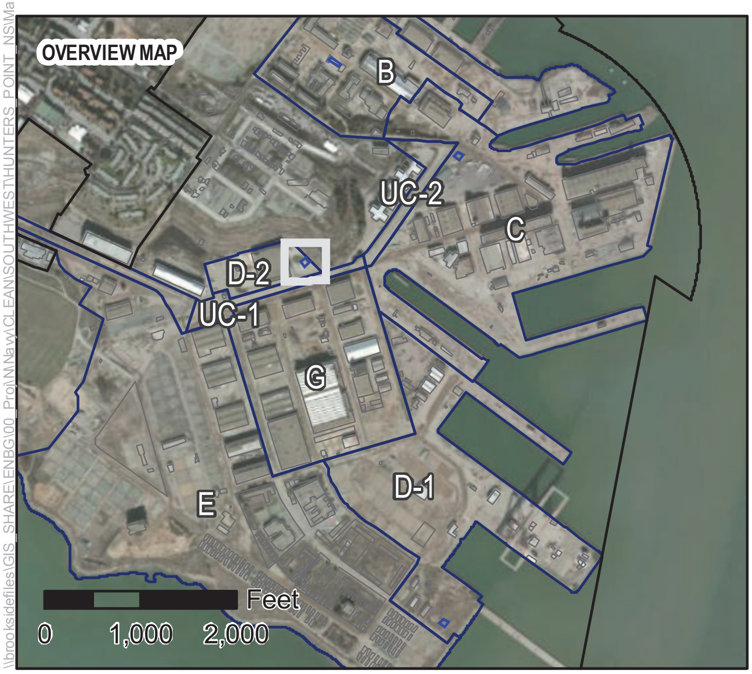


Legend:

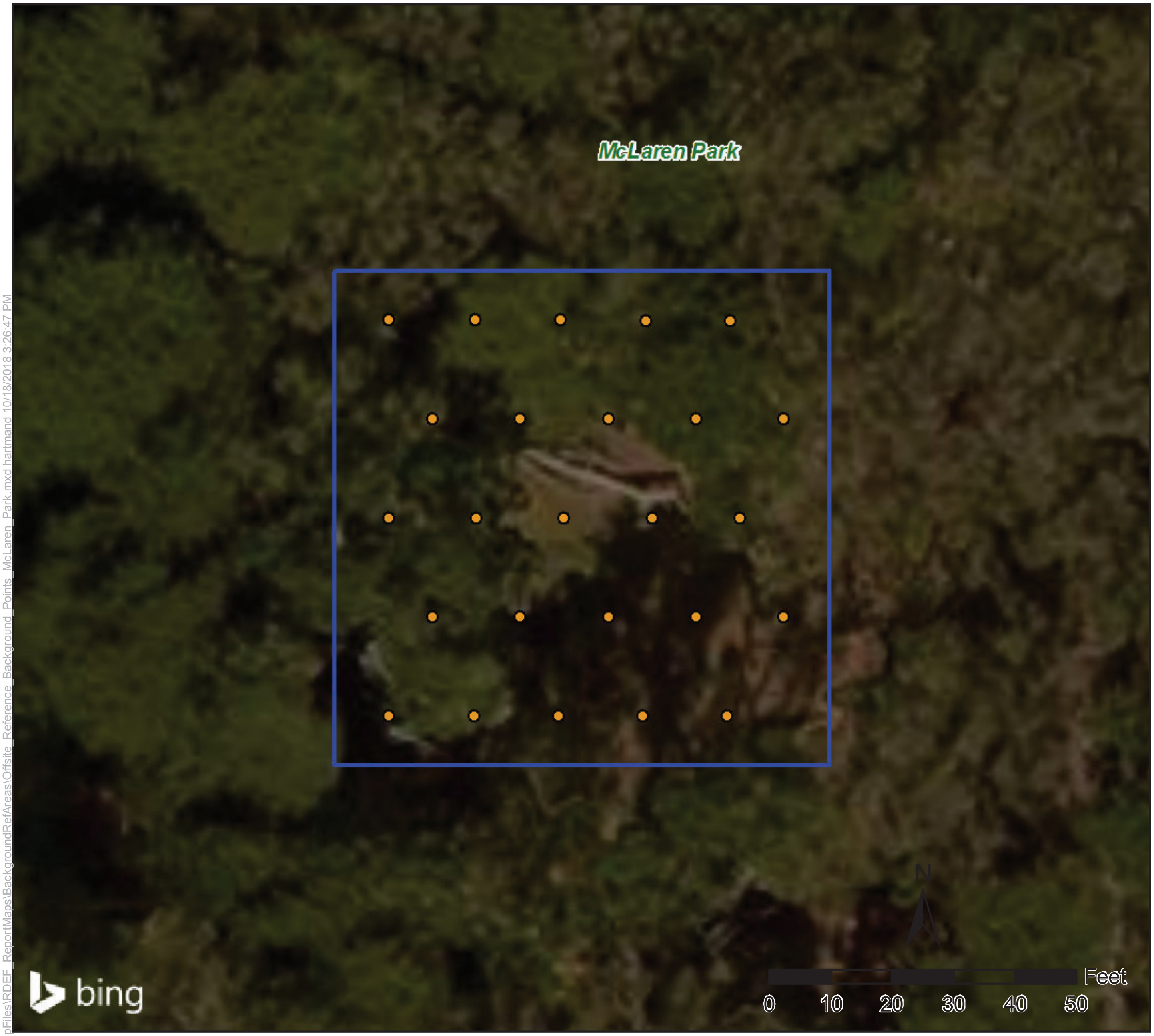
- Surface Sample Location
- Surface and Subsurface Sample Location
- Reference Background Area
- Installation Boundary
- Parcel Boundary
- Current and Former Building Site

COORDINATE SYSTEM:
NAD 1983 StatePlane California III FIPS 0403 Feet

BASE MAP SOURCE:
Service Layer Credits: Source: Esri, DigitalGlobe, GeoEye, Earthstar Geographics, CNES/Airbus DS, USDA, USGS, AeroGRID, IGN, and the GIS User Community

Figure 3-7
HPNS Reference Background Area RBA-4
Soil Reference Background Area Work Plan
Former Hunters Point Naval Shipyard
San Francisco, California

\\brooksidefiles\GIS_SHARE\ENBG\00_Proj\N\Navy\CLEAN\SOUTHWEST\HUNTERS_POINT_NS\MapFiles\RDEF_ReportMaps\BackgroundRefAreas\Hunters_Point_Background_points.mxd hartmand 9/26/2018 4:25:36 PM



Legend:

- Surface and Subsurface Sample Location
- Reference Background Area*
- Park

* NOTE: The exact location of the RBA within McLaren Park may be adjusted based on consultation with the City of San Francisco.

COORDINATE SYSTEM: NAD 1983 StatePlane California III FIPS 0403 Feet

BASE MAP SOURCE: Service Layer Credits: © 2018 Microsoft Corporation © 2018 DigitalGlobe ©CNES (2018) Distribution Airbus DS

Park Lands layer developed by the San Francisco Recreation and Parks Department (2016).

Figure 3-8
McLaren Park Reference Background Area RBA-McLaren
Soil Reference Background Area Work Plan
Former Hunters Point Naval Shipyard
San Francisco, California

SECTION 4

Data Evaluation and Reporting

Various types of radiological data are being collected from multiple RBAs during the execution of this work plan, from soils with potentially different distributions of naturally occurring and fallout radionuclides. Gamma scan data will be mapped and evaluated as detailed in **Section 4.1**. Analytical data (i.e., soil sample results) will be compiled and validated in accordance with the SAP. Following data validation, analytical sample results will be evaluated as detailed in **Section 4.2**. Once data is obtained and evaluated, the statistical data evaluation process will be presented to the regulatory agencies for concurrence. Following evaluation, the RBA characterization data will be compiled and submitted in a Soil RBA Report as detailed in **Section 4.4**.

4.1 Gamma Scan Data Evaluation

Gamma scan survey data from each RBA will be initially evaluated as individual RBA data sets for both gross gamma and gamma spectra. The purposes of the data evaluation are the following:

- Conduct a preliminary data review and compile basic statistics
- Perform graphical data review
- Identify outliers or data that are not representative of background conditions

4.1.1 Conduct a Preliminary Data Review

The spectra will be analyzed using regions of interest for known gamma-emitting ROCs and naturally occurring radionuclides. Radionuclide-specific (spectra) and gross gamma data set information will be gleaned by reviewing the distribution of the data; compiling basic statistics, including mean, median, minimum, maximum, and standard deviation; and creating plots such as histograms, box plots, and probability plots from each RBA.

Because position measurements were collected in conjunction with the radiological readings, gamma survey maps will be generated using the GPS locations to visually evaluate the geospatial measurements and to confirm the RBA classifications as being non-impacted and suitable for use as RBAs. The gamma survey map will be created as follows:

- Using GIS software, the gamma measurement will be spatially plotted using the GPS coordinates recorded during the scan survey.
- Measurements collected outside of the RBA footprints will be digitally cropped out of the survey maps so that only the designated RBAs will contain gamma measurements.
- Using contouring functions in GIS, a contiguous surface will be created and color-coded for visualization of the readings.

4.1.2 Identify Outliers

The gamma scan survey data will undergo an outlier evaluation using Dixon's and Rosner's outlier tests, supplemented by graphical plots. Dixon's test is valid for data sets with up to 25 data points while Rosner's test is recommended for larger data sets. Details of Dixon's and Rosner's tests for outliers are provided in **Section 4.2.2**. Both Dixon's and Rosner's tests assume that the data values (aside from those being tested as potential outliers) are normally distributed. Because environmental data tend to be right-skewed, a test that relies on an assumption of a normal distribution may identify a relatively large number of mathematical outliers. Outliers identified in this evaluation will be reviewed to determine that the outliers are attributable to elevated radioactivity or find out if any other causes (e.g., a potential electronics error) exist. If elevated scan measurements are observed, follow-up investigations may be performed with static measurements to delineate and characterize potential areas of interest. Areas with elevated scan measurements that are attributed to contamination or discrete radiological objects will not be sampled, and alternate locations will be selected.

4.2 Analytical Data Evaluation

A statistical data evaluation will be conducted to identify appropriate soil background data sets and calculate descriptive statistics to facilitate future comparisons with site-specific data. The purposes of the data evaluation are the following:

- Conduct a preliminary data review, which includes the following tasks:
  - Compile basic statistics
  - Perform graphical data review
- Identify outliers or data that are not representative of background conditions.
- Conduct statistical tests, including determining statistical differences between data sets.
- Review equilibrium conditions of naturally occurring radionuclides.

4.2.1 Conduct a Preliminary Data Review

Analytical data set information will be reviewed by compiling basic statistics, including mean, median, minimum, maximum, and standard deviation. Graphical comparisons will be made using posting plots, histograms, box-and-whisker plots, quantile-quantile plots, and normal probability plots from each RBA. Review of the basic statistics and plots will provide useful information, such as revealing homogeneity or heterogeneities, spatial trends, data distributions, and skewness. RBA data from individual RBAs are assumed to follow a normal or log-normal distribution without bi-modalities or skewness. The results of the normality testing can be used to validate a data set as being consistent with assumptions concerning background.

4.2.2 Identify Outliers

Graphs of analytical data will be reviewed for indications of data values outside of the expected distribution (i.e., potential outliers). In addition, outlier evaluations will be performed using Dixon's and Rosner's tests or other appropriate tests, including non-parametric methods. Data review will be conducted initially using the current version of the USEPA's ProUCL tool, which uses Dixon's and Rosner's tests as well as box plots and quantile-quantile (Q-Q) plots to identify outliers. Tests for normality will be performed both prior to and following treatment for outliers. If data sets do not appear normally distributed following removal of outliers and more robust outlier detection methods beyond the scope of ProUCL are required, USEPA will be consulted. The following paragraphs provide additional details about the performance of Dixon's and Rosner's tests for outliers.

Dixon's test is valid for data sets with up to 25 data points while Rosner's test is recommended for larger data sets. Both Dixon's and Rosner's tests assume that the data values (aside from those being tested as potential outliers) are normally distributed. Both statistical outlier tests will be performed using statistical software or spreadsheets and are described here. The Dixon test will be performed by arranging the concentrations of a specific nuclide in ascending order from X_1 to X_N and using **Equation 4-1**:

Equation 4-1

$$Q_{exp} = \frac{X_2 - X_1}{X_N - X_1}$$

Where:

Q_{exp} = experimental Q-value

X_N = highest value of measurements

X_1 = value of smallest measurement

X_2 = value of second smallest measurement

The corresponding Q_{exp} value is compared to the critical value (Q_{crit}) obtained from a confidence level of 95 percent.

Because Dixon's test is appropriate for samples sizes with up to 25 data points, Rosner's test for outliers will be performed for sample sizes larger than 25. The Rosner's test is performed as follows:

- Arrange the concentrations of a specific nuclide in ascending order, and by simple inspection, identify the maximum number of possible outliers r_0.
- Compute the mean and standard deviation of the data and determine the measurement furthest from the mean.
- Delete the measurement from the data set and compute the sample mean and standard deviation from the remaining observations. Again, find the value in the reduced data set furthest from the mean.
- Delete the measurement and recompute the mean and standard deviation until all potential outliers have been removed.
- Perform test for outliers, using **Equation 4-2**:

Equation 4-2

$$R_{r-1} = \frac{\left| y^{(r-1)} - \bar{x}^{(r-1)} \right|}{s^{(r-1)}}$$

Where:

R_{r-1} = test statistic for potential *r* outlier

$y_{(r-1)}$ = measurement value of outlier

$x_{(r-1)}$ = mean of reduced data set without $y_{(r-1)}$ value

$s_{(r-1)}$ = standard deviation of reduced data set with $y_{(r-1)}$ value

- Compare the test statistic (R_{r-1}) to the critical value corresponding to a confidence level of 95 percent.
- Perform the test statistic for the other possible outliers identified in Step 1 in the same fashion until the possible outliers have either been identified or Rosner's test finds no outliers.

Because environmental data tend to be right-skewed, a test that relies on an assumption of a normal distribution may identify a relatively large number of mathematical outliers. Outliers identified in this evaluation will be reviewed to determine whether any suitable reasons (e.g., a potential analytical error) exist to exclude them from further calculations. Confirmed outliers will be removed from individual data sets.

4.2.3 Conduct Statistical Tests

Background concentrations from each RBA for surface soil and subsurface soil will be compared statistically to test for differences between surface soil and subsurface soil concentrations and to test for differences among soil types. If the data sets are not significantly different, then they will be combined to create a larger background data set. If the data sets are significantly different, then they will be treated separately for comparisons of site-specific data to background.

In addition to graphical inspection, central tendency comparisons will be performed to determine whether the centers of the distributions of the surface soil and subsurface soil data, and between the various soil types, are different or similar. Statistical tests for a normal distribution (symmetry) will be performed using computer software to conduct the Shiparo-Wilk/Lillifors testing for normality.

The RBA data sets will be compared to each other by applying the KW statistical test, detailed in Section 13.2 of NUREG-1505 (NRC, 1998a) to determine whether the reference areas have similar or significantly different background levels. If data sets are similar (i.e., pass the KW test), they may be combined. If data sets are significantly different (i.e., fail the KW test), further evaluation will be performed to determine the potential causes of the differences, such as soil type or depth bgs. Data may be plotted on site maps or plotted against gamma-scan data to look for visual clues as to ROC distribution and to evaluate spatial independence.

4.2.4 Review Equilibrium Conditions

The RBA data sets for ^{226}Ra and other naturally occurring ROCs will be selected to represent as much of the soil at HPNS as practical. However, the history of HPNS shows that a wide variety of fill materials have been used as part of construction and maintenance activities over the life of the site. These fill materials may have a wide range of naturally occurring radioactivity and could result in an incorrect identification of fill material with higher levels of NORM being identified as contamination. To avoid this situation, the Navy may perform additional evaluation of investigation samples where the ^{226}Ra gamma spectroscopy result exceeds the RG and the expected range of background but could still be associated with NORM instead of contamination.

The uranium natural decay series is one of the primordial natural decay series that are collectively referred to as NORM. The members of the uranium natural decay series are present in background at concentrations that are approximately equal, a situation referred to as secular equilibrium. Secular equilibrium for the uranium natural decay series is established over hundreds of thousands of years. Concentrations of ^{226}Ra higher than the concentrations of other members of the uranium natural decay series may indicate contamination, while ^{226}Ra concentrations consistent with other members of the series indicate natural background.

Determining the equilibrium status of the uranium natural decay series requires analyzing a sample for multiple radionuclides from the series using the same or comparable analytical techniques. Observed differences in concentrations result primarily from differences in concentrations, and the uncertainty is primarily associated with the analysis.

Radionuclides from the uranium natural decay series with ^{226}Ra as a decay product (i.e., ^{238}U, ^{234}U, and ^{230}Th) will be analyzed by alpha spectroscopy, along with ^{226}Ra. It is not necessary to analyze for the decay products of ^{226}Ra because these radionuclides re-establish secular equilibrium with ^{226}Ra over a period of several weeks. In addition, most of the ^{226}Ra decay products are not readily analyzed by alpha spectroscopy.

Alpha spectroscopy will be performed for uranium isotopes (^{238}U, ^{235}U, ^{234}U), thorium isotopes (^{232}Th, ^{230}Th, and ^{228}Th), and ^{226}Ra. If practical, the analyses will be performed using the same sample aliquot to reduce sampling uncertainty. The results of the four analyses will be compared, and the ratio between the ^{226}Ra and the other three radionuclides will be calculated to evaluate whether the radionuclides are in secular equilibrium.

4.2.5 Establish Background Data Sets

Once a determination has been made about combining data from the RBAs, one or more RBA data sets for each radionuclide will be established. Pending approval for their use, the data sets will be used for comparison with trench or surface soil data sets as described in the Parcel G Work Plan.

While the focus of the analytical evaluation will be on radioactivity, the evaluations may also identify and record relationships and correlations between lithologic characteristics of the samples and the radioactivity.

4.3 Review of Other RBA Data Sources

The history of HPNS shows that a wide variety of fill materials have been used as part of construction and maintenance activities over the life of the site. These fill materials may have a wide range of naturally occurring radioactivity. In order to gain a more comprehensive understanding of background conditions, previous offsite background studies that have been performed in and around the Bay Area over the past 20 years will be evaluated. Studies performed by the U.S. Geological Survey (USGS) (Bouse et al., 2010; Fuller et al., 1998; Nilsen et al., 2015; Higgins et al., 2007), Navy, and Lawrence Berkeley National Lab, among others, will be evaluated to determine whether the data may be comparable or representative of materials at HPNS. Review of the available information from the offsite studies will include analytical results of ROCs and NORM constituents, analytical methods, soil lithology, and geographic latitude.

4.4 Reporting

Following completion of RBA soil data evaluation, a report will be prepared to include a summary of the field activities, any deviations from the work plan, results of gamma scan surveys, and analytical and geotechnical data (including full data packages from the analytical laboratory and third-party validation reports), along with the results of the data evaluation. Based on the statistical evaluations, the report will include recommendations for combining similar data sets, and recommendations for selecting values or data sets representing background in soil, and conditions identifying situations when specific values or data sets may not be appropriate. Information from other San Francisco Bay Area radiological background studies may be referenced in the report as appropriate. If additional areas are selected for sampling, if other background data sets are identified, or if USGS is involved and provides input, details and justification will be provided in the report. The draft report will be submitted for regulatory review, and meetings will be held to discuss the results and facilitate consensus on appropriate background values prior to finalizing the report.

SECTION 5

Radioactive Materials Management and Control

This work plan was prepared based on CH2M HILL, Inc. (CH2M) and its subcontractor, Perma-Fix, leading and conducting the field activities presented in this work plan. Prior to initiating field activities at HPNS, Perma-Fix will invoke their Radioactive Material License, as described in the Parcel G Work Plan. The Parcel G Work Plan includes the following contractor-specific information: Radioactive Material License, SOPs, Organizational Chart, and Radiation Protection Plan. The APP/SSHP outlines the health and safety requirements and procedures for the field activities included in this work plan.

References

Bouse, R. M., C.C. Fuller, S. Luoma, M.I. Hornberger, B.E. Jaffe, and R.E. Smith. 2010. "Mercury-Contaminated Hydraulic Mining Debris in San Francisco Bay." *San Francisco Estuary and Watershed Science*. Vol. 8(1).

Fuller C.C., A. van Geen, M. Baskaran, and R. Anima. 1998. "Sediment Chronology in San Francisco Bay, California, Defined by ^{210}Pb, ^{234}Th, ^{137}Cs, and $^{239,240}Pu$." *Marine Chemistry*. Vol. 64. pp. 7-27.

Higgins S. A., B.E. Jaffe, and C.C. Fuller. 2007. "Reconstructing Sediment Age Profiles from Historical Bathymetry Changes in San Pablo Bay, California." *Estuarine Coastal and Shelf Science*. Vol. 73. pp. 165-174.

Navy. 2019. *Parcel G Removal Site Evaluation Work Plan, Former Hunters Point Naval Shipyard, San Francisco, California*. Final.

Nilsen E. B., R.J. Rosenbauer, C.C. Fuller, and B.J. Jaffe. 2015. "Sedimentary Organic Biomarkers Suggest Detrimental Effects of PAHs on Estuarine Microbial Biomass during the 20th Century in San Francisco Bay, CA, USA." *Chemosphere* Vol. 119. pp. 961-970.

Nuclear Regulatory Commission (NRC). 1998a. *A Nonparametric Statistical Methodology for the Design and Analysis of Final Status Decommissioning Surveys*. NUREG-1505. Revision 1.

Nuclear Regulatory Commission (NRC). 1998b. *Minimum Detectable Concentrations with Typical Radiation Survey Instruments for Various Contaminants and Field Conditions*. NUREG-1507. Washington, D.C. June.

United States Environmental Protection Agency (USEPA), Department of Energy, Nuclear Regulatory Commission, and Department of Defense. 2000. *Multi-Agency Radiation Survey and Site Investigation Manual (MARSSIM)*. NUREG-1575, Rev. 1. EPA 402-R-97-016, Rev. 1. DOE/EH-0624, Rev. 1. August.

Appendix D
Contractor-specific Radioactive Material License, Standard Operating Procedures, Organizational Chart, and Radiation Protection Plan

RADIOACTIVE MATERIAL LICENSE

Pursuant to the California Code of Regulations, Division 1, Title 17, Chapter 5, Subchapter 4, Group 2, Licensing of Radioactive Material, and in reliance on statements and representations heretofore made by the licensee, a license is hereby issued authorizing the licensee to receive, use, possess, transfer, or dispose of radioactive material listed below; and to use such radioactive material for the purpose(s) and at the place(s) designated below. This license is subject to all applicable rules, regulations, and orders of the California Department of Public Health now or hereafter in effect and to any standard or specific condition specified in this license.

1. *Licensee:* Perma-Fix Environmental Services, Inc	3. *License Number:* 8188-07 *Amendment Number*: 2
2. *Address:* **1093 Commerce Park Drive, Suite 300** **Oak Ridge, TN 37830**	4. *Expiration date:* June 6, 2027 (3)
Attention: **Samuel** Eric Miller, CHP Radiation Safety Officer	5. *Inspection agency:* Radiologic Health Branch North

In response to the letter dated March 7, 2018, signed by Samuel Eric Miller, Corporate Radiation Safety Officer, License Number 8188-07 is hereby amended as follows:

6. Nuclide	7. Form	8. Possession limit
A. Any byproduct material with atomic numbers 1 through 83	A. Any	A. Total not to exceed 18.5 gigabecquerels (500 millicuries).
B. Any byproduct material with atomic numbers 84 through 103	B. Any	B. Total not to exceed 37 megabecquerels (1 millicurie)
C. Radium-226	C. Any	C. Total not to exceed 18.5 gigabecquerels (500 millicuries).
D. Any Source Material	D. Any	D. Not to exceed 200 kilograms (441 pounds).
E. Any Special Nuclear Material	E. Any	E. Total not to exceed 2 grams, Plutonium-238 not to exceed 0.9 grams.

9. Authorized Use

A. - E. To be used for site characterization, decontamination, decommissioning, final status survey, packaging waste for transport, preparation and analysis of samples from various media as a customer service, and incidental to use for operational testing of radiation detection instruments.

LICENSE CONDITIONS

10. Radioactive material shall be used only at the following locations:

(a) Temporary job sites of the licensee in areas not under exclusive (see Condition 21) federal jurisdiction throughout the State of California.

11. This license is subject to an annual fee for sources of radioactive material authorized to be possessed at any one time as specified in Items 6, 7, 8 and 9 of this license. The annual fee for this license is required by and computed in accordance with Title 17, California Code of Regulations, Sections 30230-30232 and is also subject to an annual cost-of-living adjustment pursuant to Section 100425 of the California Health and Safety Code.

RADIOACTIVE MATERIAL LICENSE

License Number: 8188-07

Amendment Number: 2

12. Radioactive material shall be used by, or under the supervision of, the following individuals:

    (a) Jason Hubler
    (b) Andrew J. Lombardo, CHP
    (c) Samuel Eric Miller, CHP
    (d) Scott Walnicki
    (e) Jeffery L. Knight
    (f) Eric J. Laning
    (g) Brian Miller
    (h) Steve Green, CHP
    (i) Darin McEleney
    (j) Andrew Williams
    (k) Alejandro Lopez, CHP
    (l) Javid Kelley, CHP

13. Except as specifically provided otherwise by this license, the licensee shall possess and use radioactive material described in Items 6, 7, 8 and 9 of this license in accordance with the statements, representations, and procedures contained in the documents listed below. The Department's regulations shall govern unless the statements, representations, and procedures in the licensee's application and correspondence are more restrictive than the regulations.

    (a) The application dated December 16, 2016, with attachments, signed by Samuel Eric Miller, Radiation Safety Officer and attached Delegation of Authority form, dated December 16, 2016, signed by Andrew J. Lombardo, Senior Vice President and as revised by the letters dated March 14, 2017, and April 7, 2017, both with attachments, and both signed by Samuel Eric Miller, Radiation Safety Officer.

14. (a) The Radiation Safety Officer in this program shall be Samuel Eric Miller, CHP.

15. Except for calibration sources, reference standards, and radioactively contaminated equipment owned by the licensee, possession of licensed material at each temporary job site shall be limited to material originating from each site. This material must either be transferred to an authorized recipient or remain at the site after licensee activities are completed.

16. (a) At least 14 days before initiating activities at a temporary job site, including military or former military sites where the temporary job site is not under exclusive federal jurisdiction, the licensee shall notify, in writing, the California Department of Public Health, Radiologic Health Branch. The notification shall include the following information:

    i. Site-specific radiological procedures if they have not been previously approved by the Department of Public Health.
    ii. Estimated type, quantity, and physical/chemical forms of radioactive material.
    iii. Specification of the site location.
    iv. Description of project activities that are planned for the site, including management and disposition of radioactive material.
    v. Estimated project start date and duration of project.
    vi. Name, address, title, and phone number of a point of contact for the person managing radiological operations at the temporary job site.

    (b) Within 30 days of completing activities at each job site, the licensee shall notify, in writing, the California Department of Public Health, Radiologic Health Branch, regarding the radiological status of the temporary job site and the disposition of any licensed radioactive material.

RADIOACTIVE MATERIAL LICENSE

17. This license does not authorize the use of licensed material at temporary job sites for uses already specifically authorized by a customer's license. If a customer also holds a license issued by the NRC or an Agreement State, the licensee shall establish a written agreement between the licensee and the customer specifying which licensee activities shall be performed under the customer's license and supervision, and which licensee activities shall be performed under the licensee's supervision pursuant to this license. The agreement shall include a commitment by the licensee and the customer to ensure safety, and any commitments by the licensee to help the customer clean up the temporary job site if there is an accident. A copy of this agreement shall be included in the notification required by License Condition 16.

18. The licensee shall maintain records of information important to decommissioning each temporary job site at the applicable job site pursuant to Title 17, California Code of Regulations, Section 30256. The records shall be made available to the Department for inspection and to the customer upon request during decommissioning activities, and shall be transferred to the customer for retention at the completion of activities at a temporary job site.

19. The licensee shall comply with all requirements of Title 17, California Code of Regulations, Section 30373 when transporting or delivering radioactive materials to a carrier for shipment. These requirements include; packaging, marking, labeling, loading, storage, placarding, monitoring, and accident reporting. Shipping papers shall be maintained for inspection pursuant to the U.S. Department of Transportation requirements (Title 49, Code of Federal Regulations, Part 172, Sections 172.200 through 172.204).

20. The total mass of special nuclear material possessed under this license at any one time or at any one authorized location of use shall not exceed that stated in the following formula: The number of grams of Uranium 235 divided by 350, plus the number of grams of Uranium 233 divided by 200, plus the number of grams of Plutonium (all isotopes) divided by 200, shall not exceed one (i.e. unity).

21. Before radioactive materials may be used at a temporary job site at any federal facility, the jurisdictional status of the job site must be determined. If the jurisdictional status is unknown, the federal agency should be contacted to determine if the job site is under exclusive federal jurisdiction. A response shall be obtained in writing or a record made of the name and title of the person at the federal agency who provided the determination and the date that it was provided. Authorization for use of radioactive materials at the job sites under exclusive federal jurisdiction shall be obtained either by:

    (a) Filing an NRC Form-241 in accordance with the Code of Federal Regulations, Title 10, Part 150.20 (b), "Recognition of Agreement State Licenses", or

    (b) By applying for a specific NRC license.

    Before radioactive material can be used at a temporary job site in another State, authorization shall be obtained from the State if it is an Agreement State, or from the NRC for any non-Agreement State, either by filing for reciprocity or applying for a specific license.

22. In accordance with the California Code of Regulations Title 17, Section 30195.1, the licensee shall maintain an acceptable financial instrument in the amount of $52,000.00 that satisfies the requirements outlined in the decommissioning funding plan dated December 16, 2016.

RADIOACTIVE MATERIAL LICENSE

License Number: 8188-07

Amendment Number: 2

23. The licensee will provide the Low Level Radioactive Waste (LLRW) reports specified in the California Health and Safety Code section 115000.1(h) to the California Department of Public Health (CDPH) on an annual basis for both shipped and stored LLRW. Alternatively, LLRW shipment information may be provided on a per shipment basis. LLRW shipment information and annual reports shall be mailed to:

    Attn: LLRW Tracking Program
    California Department of Public Health
    Radiologic Health Branch, MS 7610
    P.O. Box 997414
    Sacramento, CA 95899-7414

24. At least 30 days prior to vacating any address of use listed in Condition 10 of this license, the licensee shall provide written notification of intent to vacate to the California Department of Public Health, in accordance with Title 17, California Code of Regulations, Section 30256 (b). Control of all licensed areas must be maintained until such areas are released by the Department for unrestricted use or the license is terminated, in accordance with Title 17, California Code of Regulations, Section 30256 (j).

25. A copy of this license and a copy of all records and documents pertaining to this license shall be maintained available for inspection at **4585 Pacheco Blvd., Suite 200, Martinez, CA 94553.**

26. If approved by the Radiation Safety Officer specifically identified in this license, the licensee may take reasonable action in an emergency that departs from conditions in this license when action is immediately needed to protect public health and safety and no action consistent with all license conditions that can provide adequate or equivalent protection is immediately apparent. The licensee shall notify the CDPH-RHB before, if practicable, and in any case, immediately after taking such emergency action using reporting procedure specified in 10CFR30.50(c).

Issued for the State of California Department of Public Health

Date: March 20, 2018

By:

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Application and Description of Standard Operating Procedures

SOP Number	SOP Title	Application and Purpose
CH2M Document	Soil Sampling	Provides guidelines for obtaining samples of surface and subsurface soils using hand and drilling-rig-mounted equipment.
CH2M Document	Logging of Soil Borings	Provides guidance for obtaining accurate and consistent descriptions of soil characteristics during soil sampling operations.
CH2M Document	Decontamination of Equipment and Samples	Provides general guidelines for the decontamination of sampling equipment, and monitoring equipment used in potentially contaminated environments.
CH2M Document	Preparing Field Logbooks	Provides general guidelines for entering field data into logbooks during site investigation and remediation activities.
CH2M Document	Chain-of-Custody	Provides information on chain-of-custody procedures.
CH2M Document	Packaging and Shipping Procedures for Low-concentration Samples	Provides information on preparing, packaging, and shipping low activity radioactive samples for analysis.
RP-100	Radiation Protection Program	Describes the major elements of the Radiation Protection Program.
RP-102	Radiological Posting	Identifies the types of postings necessary and requirements to clearly identify radiological conditions in a specific area or location within an area for consistent posting and control of RCAs. It also specifies the requirements for access into and egress from RCAs.
RP-103	Radiation Work Permits Preparation and Use	Provides direction on the requirements of the application, preparation, approval, issuance, and use of general and specific Radiation Work Permits.
RP-104	Radiological Surveys	Specifies methods and requirements for radiological surveys, and the documentation required for the acquired survey data.
RP-105	Unrestricted Release Requirements	Describes the method of surveying equipment, materials, or vehicles for release for unrestricted use.
RP-106	Survey Documentation and Review	Provides the methodology for documenting radiological surveys and provides criteria for the review of these surveys.
RP-107	Measurement of Airborne Radioactivity	Provides the basis and methodology for the placement and use of air monitoring equipment, as well as the collection, analysis, and documentation of air samples.
RP-108	Count Rate Instruments	Provides the methods for setup, daily pre-operational check, and operation of portable count-rate survey instruments.
RP-109	Dose Rate Instruments	Provides the methods for performing source checks and operating portable gamma scintillation dose rate instruments, specifically, the Ludlum Model 12s uR and the Bicron Model Micro Rem.
RP-111	Radioactive Materials Control and Waste Management Plan	Provides guidance and requirements for the control of radioactive materials, including the management of radioactive waste.
RP-112	Dosimetry Issue	Provides consistent methodology for the issuance of radiation monitoring dosimetry devices.

Application and Description of Standard Operating Procedures

SOP Number	SOP Title	Application and Purpose
RP-114	Control of Radiation Protection Records	Describes the requirements for controlling Radiation Protection Program records. It also establishes the requirements for review and temporary storage of these records.
RP-115	Radiation Worker Training	Provides consistent methodology for implementing Radiation Worker Training.
RP-130	Event Reporting and Notification for State of California	Provides a list of California regulatory contacts, a checklist for initiating emergency notifications, and general guidance for notification of incidents.
RP-132	Radiological Protective Clothing Selection, Monitoring, and Decontamination	Provides the guidance for selecting protective clothing, performing personnel surveys, and decontaminating personnel.

Note:
RCA = radiologically controlled area

Soil Sampling

I. Purpose and Scope

The purpose of this procedure is to provide guidelines for obtaining samples of surface and subsurface soils using hand and drilling-rig mounted equipment.

II. Equipment and Materials

- Stainless-steel trowel, shovel, scoop, coring device, hand auger, or other appropriate hand tool
- Split-spoon samplers
- Thin-walled sampling tubes
- Drilling rig or soil-coring rig
- Stainless-steel pan/bowl or disposable sealable bags
- Sample bottles

III. Procedures and Guidelines

Before sampling begins, equipment will be decontaminated using the procedures described in SOP *Decontamination of Drilling Rigs and Equipment*. The sampling point is located and recorded in the field logbook. Debris should be cleared from the sampling location.

A. Surface and Shallow Subsurface Sampling

A shovel, post-hole digger, or other tool can be used to remove soil to a point just above the interval to be sampled. A decontaminated sampling tool will be used to collect the sample when the desired sampling depth has been reached. Soil for semivolatile organic and inorganic analyses is placed in the bowl and mixed; soil for volatile organic analysis is not mixed or composited but is placed directly into the appropriate sample bottles. A stainless-steel trowel or disposable plastic scoop is used to transfer the sample from the bowl to the container.

The soils removed from the borehole should be visually described in the field log book, including approximated depths.

When sampling is completed, photo-ionization device (PID) readings should be taken directly above the hole, and the hole is then backfilled.

More details are provided in the SOP *Shallow Soil Sampling*.

B. Split-Spoon Sampling

Using a drilling rig, a hole is advanced to the desired depth. For split-spoon sampling, the samples are then collected following the ASTM D 1586 standard (attached). The sampler is lowered into the hole and driven to a depth equal to the total length of the sampler; typically, this is 24 inches. The sampler is driven in 6-inch increments using a 140-pound weight ("hammer") dropped from a height of 30 inches. The number of hammer blows for each 6-inch interval is counted and recorded. To obtain enough volume of sample for subsequent laboratory analysis, use of a 3-inch ID sampler may be required. Blow counts obtained with a 3-inch ID spoon would not conform to ASTM D 1586 and would therefore not be used for geotechnical evaluations.

Once retrieved from the hole, the sampler is carefully split open. Care should be taken not to allow material in the sampler to fall out of the open end of the sampler. To collect the sample, the surface of the sample should be removed with a clean tool and disposed of. Samples collected for volatiles analysis should be placed directly into the sample containers from the desired depth in the split spoon. Material for samples for all other parameters should be removed to a decontaminated stainless-steel tray or disposable sealable bag. The sample for semivolatile organic and inorganic analyses should be homogenized in the field by breaking the sample into small pieces and removing gravel. The homogenized sample should be placed in the sample containers. If sample volume requirements are not met by a single sample collection, additional sample volume may be obtained by collecting a sample from below the sample and compositing the sample for non-volatile parameters only.

Split-spoon samples also will be collected using a tripod rig. When using a tripod rig the soil samples are collected using an assembly similar to that used by the drilling rig.

C. Thin-Walled Tube Sampling

Undisturbed fine grained samples may be collected for analysis for geotechnical parameters such as vertical hydraulic conductivity. These samples will be collected using thin-walled sampling tubes (sometimes called Shelby tubes) according to ASTM D 1587 (attached). Tubes will be 24- to 36 inches long and 3- to 4-inches in diameter, depending upon the quantity of sample required. Undisturbed samples will be obtained by smoothly pressing the sampling tube through the interval to be sampled using the weight of the drilling rig. Jerking the sample should be avoided. Once the sample is brought to the surface, the ends will be sealed with bees wax and then sealed with end caps and heavy tape. The sample designation, data and time of sampling, and the up direction will be noted on the sampling tube. The tube shall be kept upright as much as possible and will be protected from freezing, which could disrupt the undisturbed nature of the sample. Samples for geochemical analysis normally are not collected from thin-walled tube samples.

IV. Attachments

ASTM D 1586 *Standard Penetration Test Method for Penetration Test and Split-Barrel Sampling of Soils* (ASTM D1586.pdf)

ASTM D 1587 *Standard Practice for Thin-Walled Tube Sampling of Soils* (ASTM D1587.pdf)

V. Key Checks and Preventative Maintenance

- Check that decontamination of equipment is thorough.
- Check that sample collection is swift to avoid loss of volatile organics during sampling.

Designation: D 1586 – 08

Standard Test Method for Standard Penetration Test (SPT) and Split-Barrel Sampling of Soils[1]

This standard is issued under the fixed designation D 1586; the number immediately following the designation indicates the year of original adoption or, in the case of revision, the year of last revision. A number in parentheses indicates the year of last reapproval. A superscript epsilon (ε) indicates an editorial change since the last revision or reapproval.

This standard has been approved for use by agencies of the Department of Defense.

1. Scope*

1.1 This test method describes the procedure, generally known as the Standard Penetration Test (SPT), for driving a split-barrel sampler to obtain a representative disturbed soil sample for identification purposes, and measure the resistance of the soil to penetration of the sampler. Another method (Test Method D 3550) to drive a split-barrel sampler to obtain a representative soil sample is available but the hammer energy is not standardized.

1.2 Practice D 6066 gives a guide to determining the normalized penetration resistance of sands for energy adjustments of N-value to a constant energy level for evaluating liquefaction potential.

1.3 Test results and identification information are used to estimate subsurface conditions for foundation design.

1.4 Penetration resistance testing is typically performed at 5-foot depth intervals or when a significant change of materials is observed during drilling, unless otherwise specified.

1.5 This test method is limited to use in nonlithified soils and soils whose maximum particle size is approximately less than one-half of the sampler diameter.

1.6 This test method involves use of rotary drilling equipment (Guide D 5783, Practice D 6151). Other drilling and sampling procedures (Guide D 6286, Guide D 6169) are available and may be more appropriate. Considerations for hand driving or shallow sampling without boreholes are not addressed. Subsurface investigations should be recorded in accordance with Practice D 5434. Samples should be preserved and transported in accordance with Practice D 4220 using Group B. Soil samples should be identified by group name and symbol in accordance with Practice D 2488.

1.7 All observed and calculated values shall conform to the guidelines for significant digits and rounding established in Practice D 6026, unless superseded by this test method.

1.8 The values stated in inch-pound units are to be regarded as standard, except as noted below. The values given in parentheses are mathematical conversions to SI units, which are provided for information only and are not considered standard.

1.8.1 The gravitational system of inch-pound units is used when dealing with inch-pound units. In this system, the pound (lbf) represents a unit of force (weight), while the unit for mass is slugs.

1.9 Penetration resistance measurements often will involve safety planning, administration, and documentation. This test method does not purport to address all aspects of exploration and site safety. *This standard does not purport to address all of the safety concerns, if any, associated with its use. It is the responsibility of the user of this standard to establish appropriate safety and health practices and determine the applicability of regulatory limitations prior to use.* Performance of the test usually involves use of a drill rig; therefore, safety requirements as outlined in applicable safety standards (for example, OSHA regulations,[2] NDA Drilling Safety Guide,[3] drilling safety manuals, and other applicable state and local regulations) must be observed.

2. Referenced Documents

2.1 *ASTM Standards:* [4]

D 653 Terminology Relating to Soil, Rock, and Contained Fluids

D 854 Test Methods for Specific Gravity of Soil Solids by Water Pycnometer

D 1587 Practice for Thin-Walled Tube Sampling of Soils for Geotechnical Purposes

D 2216 Test Methods for Laboratory Determination of Water (Moisture) Content of Soil and Rock by Mass

D 2487 Practice for Classification of Soils for Engineering Purposes (Unified Soil Classification System)

D 2488 Practice for Description and Identification of Soils

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[1] This method is under the jurisdiction of ASTM Committee D18 on Soil and Rock and is the direct responsibility of Subcommittee D18.02 on Sampling and Related Field Testing for Soil Evaluations.

Current edition approved Feb. 1, 2008. Published March 2008. Originally approved in 1958. Last previous edition approved in 1999 as D 1586 – 99.

[2] Available from Occupational Safety and Health Administration (OSHA), 200 Constitution Ave., NW, Washington, DC 20210, http://www.osha.gov.

[3] Available from the National Drilling Association, 3511 Center Rd., Suite 8, Brunswick, OH 44212, http://www.nda4u.com.

[4] For referenced ASTM standards, visit the ASTM website, www.astm.org, or contact ASTM Customer Service at service@astm.org. For *Annual Book of ASTM Standards* volume information, refer to the standard's Document Summary page on the ASTM website.

***A Summary of Changes section appears at the end of this standard.**

(Visual-Manual Procedure)

D 3550 Practice for Thick Wall, Ring-Lined, Split Barrel, Drive Sampling of Soils

D 3740 Practice for Minimum Requirements for Agencies Engaged in the Testing and/or Inspection of Soil and Rock as Used in Engineering Design and Construction

D 4220 Practices for Preserving and Transporting Soil Samples

D 4633 Test Method for Energy Measurement for Dynamic Penetrometers

D 5434 Guide for Field Logging of Subsurface Explorations of Soil and Rock

D 5783 Guide for Use of Direct Rotary Drilling with Water-Based Drilling Fluid for Geoenvironmental Exploration and the Installation of Subsurface Water-Quality Monitoring Devices

D 6026 Practice for Using Significant Digits in Geotechnical Data

D 6066 Practice for Determining the Normalized Penetration Resistance of Sands for Evaluation of Liquefaction Potential

D 6151 Practice for Using Hollow-Stem Augers for Geotechnical Exploration and Soil Sampling

D 6169 Guide for Selection of Soil and Rock Sampling Devices Used With Drill Rigs for Environmental Investigations

D 6286 Guide for Selection of Drilling Methods for Environmental Site Characterization

D 6913 Test Methods for Particle-Size Distribution (Gradation) of Soils Using Sieve Analysis

3. Terminology

3.1 *Definitions:* Definitions of terms included in Terminology D 653 specific to this practice are:

3.1.1 *cathead, n*—the rotating drum or windlass in the rope-cathead lift system around which the operator wraps a rope to lift and drop the hammer by successively tightening and loosening the rope turns around the drum.

3.1.2 *drill rods, n*—rods used to transmit downward force and torque to the drill bit while drilling a borehole.

3.1.3 *N-value, n*—the blow count representation of the penetration resistance of the soil. The *N*-value, reported in blows per foot, equals the sum of the number of blows (*N*) required to drive the sampler over the depth interval of 6 to 18 in. (150 to 450 mm) (see 7.3).

3.1.4 *Standard Penetration Test (SPT), n*—a test process in the bottom of the borehole where a split-barrel sampler having an inside diameter of either 1-1/2-in. (38.1 mm) or 1-3/8-in. (34.9 mm) (see Note 2) is driven a given distance of 1.0 ft (0.30 m) after a seating interval of 0.5 ft (0.15 m) using a hammer weighing approximately 140-lbf (623-N) falling 30 ± 1.0 in. (0.76 m ± 0.030 m) for each hammer blow.

3.2 *Definitions of Terms Specific to This Standard:*

3.2.1 *anvil, n*—that portion of the drive-weight assembly which the hammer strikes and through which the hammer energy passes into the drill rods.

3.2.2 *drive weight assembly, n*—an assembly that consists of the hammer, anvil, hammer fall guide system, drill rod attachment system, and any hammer drop system hoisting attachments.

3.2.3 *hammer, n*—that portion of the drive-weight assembly consisting of the 140 ± 2 lbf (623 ± 9 N) impact weight which is successively lifted and dropped to provide the energy that accomplishes the sampling and penetration.

3.2.4 *hammer drop system, n*—that portion of the drive-weight assembly by which the operator or automatic system accomplishes the lifting and dropping of the hammer to produce the blow.

3.2.5 *hammer fall guide, n*—that part of the drive-weight assembly used to guide the fall of the hammer.

3.2.6 *number of rope turns, n*—the total contact angle between the rope and the cathead at the beginning of the operator's rope slackening to drop the hammer, divided by 360° (see Fig. 1).

3.2.7 *sampling rods, n*—rods that connect the drive-weight assembly to the sampler. Drill rods are often used for this purpose.

4. Significance and Use

4.1 This test method provides a disturbed soil sample for moisture content determination, for identification and classification (Practices D 2487 and D 2488) purposes, and for laboratory tests appropriate for soil obtained from a sampler that will produce large shear strain disturbance in the sample such as Test Methods D 854, D 2216, and D 6913. Soil deposits containing gravels, cobbles, or boulders typically result in penetration refusal and damage to the equipment.

4.2 This test method provides a disturbed soil sample for moisture content determination and laboratory identification. Sample quality is generally not suitable for advanced laboratory testing for engineering properties. The process of driving the sampler will cause disturbance of the soil and change the engineering properties. Use of the thin wall tube sampler (Practice D 1587) may result in less disturbance in soft soils. Coring techniques may result in less disturbance than SPT sampling for harder soils, but it is not always the case, that is, some cemented soils may become loosened by water action during coring; see Practice D 6151, and Guide D 6169.

4.3 This test method is used extensively in a great variety of geotechnical exploration projects. Many local correlations and widely published correlations which relate blow count, or *N*-value, and the engineering behavior of earthworks and foundations are available. For evaluating the liquefaction potential of sands during an earthquake event, the *N*-value should be normalized to a standard overburden stress level. Practice D 6066 provides methods to obtain a record of normalized resistance of sands to the penetration of a standard sampler driven by a standard energy. The penetration resistance is adjusted to drill rod energy ratio of 60 % by using a hammer system with either an estimated energy delivery or directly measuring drill rod stress wave energy using Test Method D 4633.

NOTE 1—The reliability of data and interpretations generated by this practice is dependent on the competence of the personnel performing it

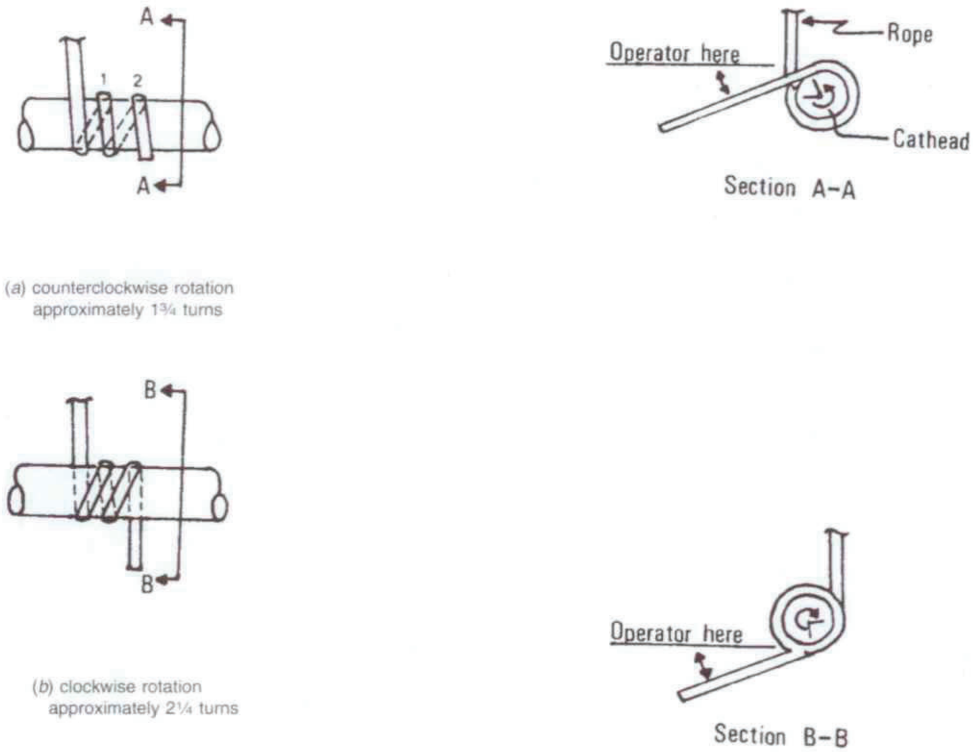


FIG. 1 Definitions of the Number of Rope Turns and the Angle for (*a*) Counterclockwise Rotation and (*b*) Clockwise Rotation of the Cathead

and the suitability of the equipment and facilities used. Agencies that meet the criteria of Practice D 3740 generally are considered capable of competent testing. Users of this practice are cautioned that compliance with Practice D 3740 does not assure reliable testing. Reliable testing depends on several factors and Practice D 3740 provides a means of evaluating some of these factors. Practice D 3740 was developed for agencies engaged in the testing, inspection, or both, of soils and rock. As such, it is not totally applicable to agencies performing this practice. Users of this test method should recognize that the framework of Practice D 3740 is appropriate for evaluating the quality of an agency performing this test method. Currently, there is no known qualifying national authority that inspects agencies that perform this test method.

5. Apparatus

5.1 *Drilling Equipment*—Any drilling equipment that provides at the time of sampling a suitable borehole before insertion of the sampler and ensures that the penetration test is performed on undisturbed soil shall be acceptable. The following pieces of equipment have proven to be suitable for advancing a borehole in some subsurface conditions:

5.1.1 *Drag, Chopping, and Fishtail Bits*, less than 6½ in. (165 mm) and greater than 2¼ in. (57 mm) in diameter may be used in conjunction with open-hole rotary drilling or casing-advancement drilling methods. To avoid disturbance of the underlying soil, bottom discharge bits are not permitted; only side discharge bits are permitted.

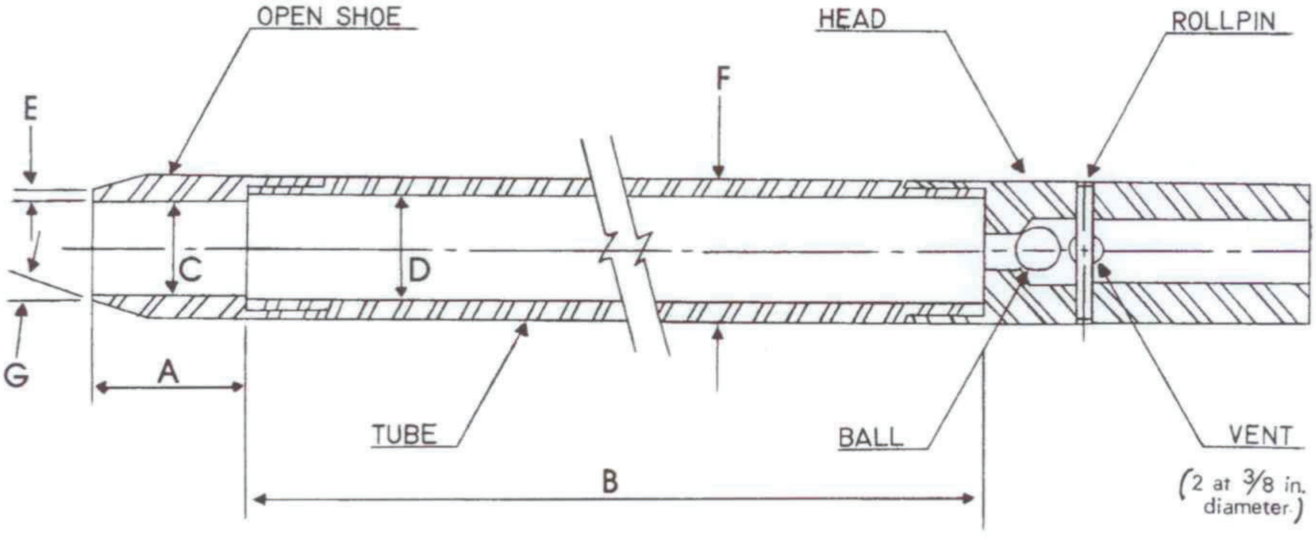
5.1.2 *Roller-Cone Bits*, less than 6½ in. (165 mm) and greater than 2¼ in. (57 mm) in diameter may be used in conjunction with open-hole rotary drilling or casing-advancement drilling methods if the drilling fluid discharge is deflected.

5.1.3 *Hollow-Stem Continuous Flight Augers*, with or without a center bit assembly, may be used to drill the borehole. The inside diameter of the hollow-stem augers shall be less than 6½ in. (165 mm) and not less than 2¼ in. (57 mm).

5.1.4 *Solid, Continuous Flight, Bucket and Hand Augers*, less than 6½ in. (165 mm) and not less than 2¼ in. (57 mm) in diameter may be used if the soil on the side of the borehole does not cave onto the sampler or sampling rods during sampling.

5.2 *Sampling Rods*—Flush-joint steel drill rods shall be used to connect the split-barrel sampler to the drive-weight assembly. The sampling rod shall have a stiffness (moment of inertia) equal to or greater than that of parallel wall "A" rod (a steel rod that has an outside diameter of 1-5/8 in. (41.3 mm) and an inside diameter of 1-1/8 in. (28.5 mm).

5.3 *Split-Barrel Sampler*—The standard sampler dimensions are shown in Fig. 2. The sampler has an outside diameter of 2.00 in. (50.8 mm). The inside diameter of the of the split-barrel (dimension D in Fig. 2) can be either 1½-in. (38.1



A = 1.0 to 2.0 in. (25 to 50 mm)
B = 18.0 to 30.0 in. (0.457 to 0.762 m)
C = 1.375 ± 0.005 in. (34.93 ± 0.13 mm)
D = 1.50 ± 0.05 – 0.00 in. (38.1 ± 1.3 – 0.0 mm)
E = 0.10 ± 0.02 in. (2.54 ± 0.25 mm)
F = 2.00 ± 0.05 – 0.00 in. (50.8 ± 1.3 – 0.0 mm)
G = 16.0° to 23.0°

FIG. 2 Split-Barrel Sampler

mm) or 1⅜-in. (34.9 mm) (see Note 2). A 16-gauge liner can be used inside the 1½-in. (38.1 mm) split barrel sampler. The driving shoe shall be of hardened steel and shall be replaced or repaired when it becomes dented or distorted. The penetrating end of the drive shoe may be slightly rounded. The split-barrel sampler must be equipped with a ball check and vent. Metal or plastic baskets may be used to retain soil samples.

NOTE 2—Both theory and available test data suggest that *N*-values may differ as much as 10 to 30 % between a constant inside diameter sampler and upset wall sampler. If it is necessary to correct for the upset wall sampler refer to Practice D 6066. In North America, it is now common practice to use an upset wall sampler with an inside diameter of 1½ in. At one time, liners were used but practice evolved to use the upset wall sampler without liners. Use of an upset wall sampler allows for use of retainers if needed, reduces inside friction, and improves recovery. Many other countries still use a constant ID split-barrel sampler, which was the original standard and still acceptable within this standard.

5.4 *Drive-Weight Assembly*:

5.4.1 *Hammer and Anvil*—The hammer shall weigh 140 ± 2 lbf (623 ± 9 N) and shall be a rigid metallic mass. The hammer shall strike the anvil and make steel on steel contact when it is dropped. A hammer fall guide permitting an unimpeded fall shall be used. Fig. 3 shows a schematic of such hammers. Hammers used with the cathead and rope method shall have an unimpeded over lift capacity of at least 4 in. (100 mm). For safety reasons, the use of a hammer assembly with an internal anvil is encouraged as shown in Fig. 3. The total mass of the hammer assembly bearing on the drill rods should not be more than 250 ± 10 lbm (113 ± 5 kg).

NOTE 3—It is suggested that the hammer fall guide be permanently marked to enable the operator or inspector to judge the hammer drop height.

5.4.2 *Hammer Drop System*—Rope-cathead, trip, semi-automatic or automatic hammer drop systems, as shown in Fig. 4 may be used, providing the lifting apparatus will not cause penetration of the sampler while re-engaging and lifting the hammer.

5.5 *Accessory Equipment*—Accessories such as labels, sample containers, data sheets, and groundwater level measuring devices shall be provided in accordance with the requirements of the project and other ASTM standards.

6. Drilling Procedure

6.1 The borehole shall be advanced incrementally to permit intermittent or continuous sampling. Test intervals and locations are normally stipulated by the project engineer or geologist. Typically, the intervals selected are 5 ft (1.5 m) or less in homogeneous strata with test and sampling locations at every change of strata. Record the depth of drilling to the nearest 0.1 ft (0.030 m).

6.2 Any drilling procedure that provides a suitably clean and stable borehole before insertion of the sampler and assures that the penetration test is performed on essentially undisturbed soil shall be acceptable. Each of the following procedures has proven to be acceptable for some subsurface conditions. The subsurface conditions anticipated should be considered when selecting the drilling method to be used.

6.2.1 Open-hole rotary drilling method.

6.2.2 Continuous flight hollow-stem auger method.

6.2.3 Wash boring method.

6.2.4 Continuous flight solid auger method.

6.3 Several drilling methods produce unacceptable boreholes. The process of jetting through an open tube sampler and

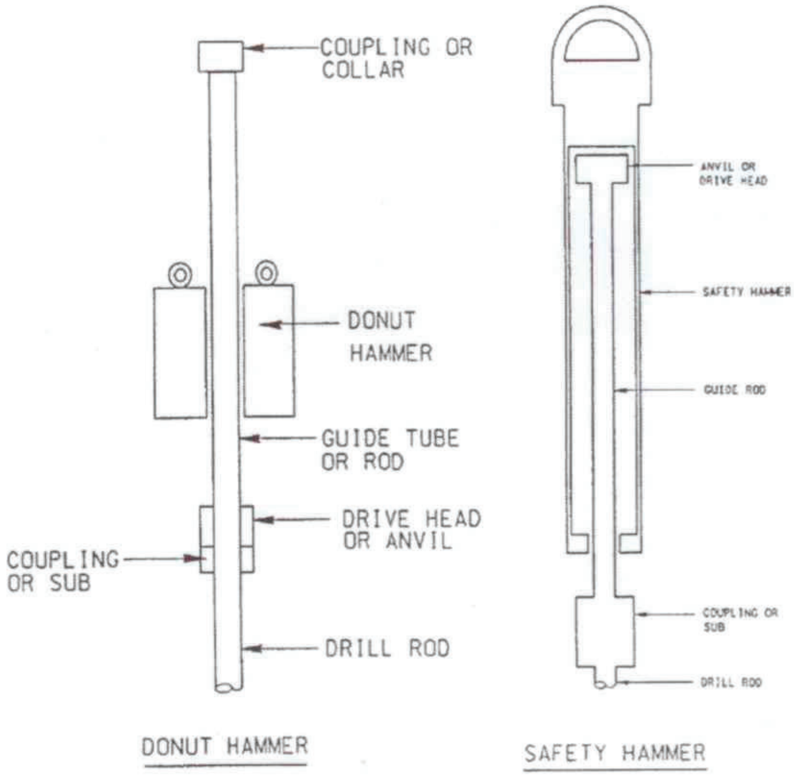


FIG. 3 Schematic Drawing of the Donut Hammer and Safety Hammer

then sampling when the desired depth is reached shall not be permitted. The continuous flight solid auger method shall not be used for advancing the borehole below a water table or below the upper confining bed of a confined non-cohesive stratum that is under artesian pressure. Casing may not be advanced below the sampling elevation prior to sampling. Advancing a borehole with bottom discharge bits is not permissible. It is not permissible to advance the borehole for subsequent insertion of the sampler solely by means of previous sampling with the SPT sampler.

6.4 The drilling fluid level within the borehole or hollow-stem augers shall be maintained at or above the in situ groundwater level at all times during drilling, removal of drill rods, and sampling.

7. Sampling and Testing Procedure

7.1 After the borehole has been advanced to the desired sampling elevation and excessive cuttings have been removed, record the cleanout depth to the nearest 0.1 ft (0.030 m), and prepare for the test with the following sequence of operations:

7.1.1 Attach either split-barrel sampler Type A or B to the sampling rods and lower into the borehole. Do not allow the sampler to drop onto the soil to be sampled.

7.1.2 Position the hammer above and attach the anvil to the top of the sampling rods. This may be done before the sampling rods and sampler are lowered into the borehole.

7.1.3 Rest the dead weight of the sampler, rods, anvil, and drive weight on the bottom of the borehole. Record the sampling start depth to the nearest 0.1 ft (0.030 m). Compare the sampling start depth to the cleanout depth in 7.1. If excessive cuttings are encountered at the bottom of the borehole, remove the sampler and sampling rods from the borehole and remove the cuttings.

7.1.4 Mark the drill rods in three successive 0.5-foot (0.15 m) increments so that the advance of the sampler under the impact of the hammer can be easily observed for each 0.5-foot (0.15 m) increment.

7.2 Drive the sampler with blows from the 140-lbf (623-N) hammer and count the number of blows applied in each 0.5-foot (0.15-m) increment until one of the following occurs:

7.2.1 A total of 50 blows have been applied during any one of the three 0.5-foot (0.15-m) increments described in 7.1.4.

7.2.2 A total of 100 blows have been applied.

7.2.3 There is no observed advance of the sampler during the application of 10 successive blows of the hammer.

7.2.4 The sampler is advanced the complete 1.5 ft. (0.45 m) without the limiting blow counts occurring as described in 7.2.1, 7.2.2, or 7.2.3.

7.2.5 If the sampler sinks under the weight of the hammer, weight of rods, or both, record the length of travel to the nearest 0.1 ft (0.030 m), and drive the sampler through the remainder of the test interval. If the sampler sinks the complete interval, stop the penetration, remove the sampler and sampling rods from the borehole, and advance the borehole through the very soft or very loose materials to the next desired sampling elevation. Record the *N*-value as either weight of hammer, weight of rods, or both.

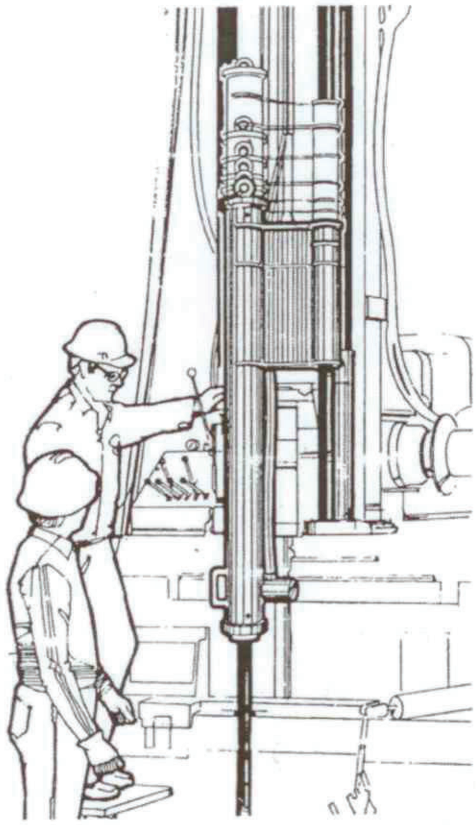


FIG. 4 Automatic Trip Hammer

7.3 Record the number of blows (N) required to advance the sampler each 0.5-foot (0.15 m) of penetration or fraction thereof. The first 0.5-foot (0.15 m) is considered to be a seating drive. The sum of the number of blows required for the second and third 0.5-foot (0.15 m) of penetration is termed the "standard penetration resistance," or the "N-value." If the sampler is driven less than 1.5 ft (0.45 m), as permitted in 7.2.1, 7.2.2, or 7.2.3, the number of blows per each complete 0.5-foot (0.15 m) increment and per each partial increment shall be recorded on the boring log. For partial increments, the depth of penetration shall be reported to the nearest 0.1 ft (0.030 m) in addition to the number of blows. If the sampler advances below the bottom of the borehole under the static weight of the drill rods or the weight of the drill rods plus the static weight of the hammer, this information should be noted on the boring log.

7.4 The raising and dropping of the 140-lbf (623-N) hammer shall be accomplished using either of the following two methods. Energy delivered to the drill rod by either method can be measured according to procedures in Test Method D 4633.

7.4.1 *Method A*—By using a trip, automatic, or semi-automatic hammer drop system that lifts the 140-lbf (623-N) hammer and allows it to drop 30 ± 1.0 in. (0.76 m ± 0.030 m) with limited unimpedence. Drop heights adjustments for automatic and trip hammers should be checked daily and at first indication of variations in performance. Operation of automatic hammers shall be in strict accordance with operations manuals.

7.4.2 *Method B*—By using a cathead to pull a rope attached to the hammer. When the cathead and rope method is used the system and operation shall conform to the following:

7.4.2.1 The cathead shall be essentially free of rust, oil, or grease and have a diameter in the range of 6 to 10 in. (150 to 250 mm).

7.4.2.2 The cathead should be operated at a minimum speed of rotation of 100 RPM.

7.4.2.3 The operator should generally use either 1-3/4 or 2-1/4 rope turns on the cathead, depending upon whether or not the rope comes off the top (1-3/4 turns for counterclockwise rotation) or the bottom (2-1/4 turns for clockwise rotation) of the cathead during the performance of the penetration test, as shown in Fig. 1. It is generally known and accepted that 2-3/4 or more rope turns considerably impedes the fall of the hammer and should not be used to perform the test. The cathead rope should be stiff, relatively dry, clean, and should be replaced when it becomes excessively frayed, oily, limp, or burned.

7.4.2.4 For each hammer blow, a 30 ± 1.0 in. (0.76 m ± 0.030 m) lift and drop shall be employed by the operator. The operation of pulling and throwing the rope shall be performed rhythmically without holding the rope at the top of the stroke.

NOTE 4—If the hammer drop height is something other than 30 ± 1.0 in. (0.76 m ± 0.030 m), then record the new drop height. For soils other than sands, there is no known data or research that relates to adjusting the N-value obtained from different drop heights. Test method D 4633 provides information on making energy measurement for variable drop heights and Practice D 6066 provides information on adjustment of N-value to a constant energy level (60 % of theoretical, N60). Practice D 6066 allows the hammer drop height to be adjusted to provide 60 % energy.

7.5 Bring the sampler to the surface and open. Record the percent recovery to the nearest 1 % or the length of sample recovered to the nearest 0.01 ft (5 mm). Classify the soil samples recovered as to, in accordance with Practice D 2488, then place one or more representative portions of the sample into sealable moisture-proof containers (jars) without ramming or distorting any apparent stratification. Seal each container to prevent evaporation of soil moisture. Affix labels to the containers bearing job designation, boring number, sample depth, and the blow count per 0.5-foot (0.15-m) increment. Protect the samples against extreme temperature changes. If there is a soil change within the sampler, make a jar for each stratum and note its location in the sampler barrel. Samples should be preserved and transported in accordance with Practice D 4220 using Group B.

8. Data Sheet(s)/Form(s)

8.1 Data obtained in each borehole shall be recorded in accordance with the Subsurface Logging Guide D 5434 as required by the exploration program. An example of a sample data sheet is included in Appendix X1.

8.2 Drilling information shall be recorded in the field and shall include the following:

8.2.1 Name and location of job,

8.2.2 Names of crew,

8.2.3 Type and make of drilling machine,

8.2.4 Weather conditions,

8.2.5 Date and time of start and finish of borehole,

8.2.6 Boring number and location (station and coordinates, if available and applicable),

8.2.7 Surface elevation, if available,

8.2.8 Method of advancing and cleaning the borehole,

8.2.9 Method of keeping borehole open,

8.2.10 Depth of water surface to the nearest 0.1 ft (0.030 m) and drilling depth to the nearest 0.1 ft (0.030 m) at the time of a noted loss of drilling fluid, and time and date when reading or notation was made,

8.2.11 Location of strata changes, to the nearest 0.5 ft (15 cm),

8.2.12 Size of casing, depth of cased portion of borehole to the nearest 0.1 ft (0.030 m),

8.2.13 Equipment and Method A or B of driving sampler,

8.2.14 Sampler length and inside diameter of barrel, and if a sample basket retainer is used,

8.2.15 Size, type, and section length of the sampling rods, and

8.2.16 Remarks.

8.3 Data obtained for each sample shall be recorded in the field and shall include the following:

8.3.1 Top of sample depth to the nearest 0.1 ft (0.030 m) and, if utilized, the sample number,

8.3.2 Description of soil,

8.3.3 Strata changes within sample,

8.3.4 Sampler penetration and recovery lengths to the nearest 0.1 ft (0.030 m), and

8.3.5 Number of blows per 0.5 foot (0.015 m) or partial increment.

9. Precision and Bias

9.1 *Precision*—Test data on precision is not presented due to the nature of this test method. It is either not feasible or too costly at this time to have ten or more agencies participate in an in situ testing program at a given site.

9.1.1 The Subcommittee 18.02 is seeking additional data from the users of this test method that might be used to make a limited statement on precision. Present knowledge indicates the following:

9.1.1.1 Variations in N-values of 100 % or more have been observed when using different standard penetration test apparatus and drillers for adjacent boreholes in the same soil formation. Current opinion, based on field experience, indicates that when using the same apparatus and driller, N-values in the same soil can be reproduced with a coefficient of variation of about 10 %.

9.1.1.2 The use of faulty equipment, such as an extremely massive or damaged anvil, a rusty cathead, a low speed cathead, an old, oily rope, or massive or poorly lubricated rope sheaves can significantly contribute to differences in N-values obtained between operator-drill rig systems.

9.2 *Bias*—There is no accepted reference value for this test method, therefore, bias cannot be determined.

10. Keywords

10.1 blow count; in-situ test; penetration resistance; soil; split-barrel sampling; standard penetration test

APPENDIX

(Nonmandatory Information)

X1. Example Data Sheet

X1.1 See Fig. 5.

DRILLERS BORING LOG

Project ______________________ Project No ______________________ Boring No ________

Location ______________________ Sheet ______ of ______

Date Started ________ Date Completed ____________

Drill Crew:

Boring Location
Station ________ Offset ________

Elevation

Strata Depth		Soil Description and Remarks	Sample Type	No.	Depth		Recovery	N-Values		
From	To				From	To		6"	6"	6"

Drill Rig Type ______________________

Method Of Drilling:

Auger ____________ Size ______________

Wash ________ Water ________ Mud ________

Hammer Type

Auto ____________ Manual ____________

Split-Spoon Type

Length ____________ Liner Used ____________

Boring Size ____________ Bit Used ____________

Casing Size ____________ Length ____________

Weather ______________________

Non-Drilling Time (Hrs.)

Boring Layout ________ Moving ________

Hauling Water ________ Standby ________

Water Level @ ________ Date ________ Time ________

@ ________ Date ________ Time ________

@ ________ Date ________ Time ________

Cave-in Depth

@ ________ Date ________ Time ________

FIG. 5 Example Data Sheet

SUMMARY OF CHANGES

Committee D18 has identified the location of selected changes to this standard since the last issue (D 1586 – 99) that may impact the use of this standard. (Approved February 1, 2008.)

(*1*) There have been numerous changes to this standard to list them separately. From the most recent main ballot process, additional changes were requested and incorporated into this newest revision. Stated below is a highlight of some of the changes.
(*2*) Scope was completely revised.
(*3*) Referenced Documents updated to include new standards.
(*4*) Terminology: added section on Definitions.
(*5*) Significance and Use: clarified use of the SPT test.
(*6*) Apparatus: general editorial changes.
(*7*) Sampling and Testing Procedure: general editorial changes.
(*8*) Data Sheets/Forms: general editorial changes.
(*9*) Precision and Bias: added Sections 9.1.1.1 and 9.1.1.2.

Designation: D 1587 – 00 (Reapproved 2007)$^{\epsilon 1}$

Standard Practice for Thin-Walled Tube Sampling of Soils for Geotechnical Purposes[1]

This standard is issued under the fixed designation D 1587; the number immediately following the designation indicates the year of original adoption or, in the case of revision, the year of last revision. A number in parentheses indicates the year of last reapproval. A superscript epsilon (ε) indicates an editorial change since the last revision or reapproval.

This standard has been approved for use by agencies of the Department of Defense.

ε[1] NOTE—Editorial changes were made in June 2007.

1. Scope*

1.1 This practice covers a procedure for using a thin-walled metal tube to recover relatively undisturbed soil samples suitable for laboratory tests of engineering properties, such as strength, compressibility, permeability, and density. Thin-walled tubes used in piston, plug, or rotary-type samplers should comply with Section 6.3 of this practice which describes the thin-walled tubes.

NOTE 1—This practice does not apply to liners used within the samplers.

1.2 This Practice is limited to soils that can be penetrated by the thin-walled tube. This sampling method is not recommended for sampling soils containing gravel or larger size soil particles cemented or very hard soils. Other soil samplers may be used for sampling these soil types. Such samplers include driven split barrel samplers and soil coring devices (D 1586, D 3550, and D 6151). For information on appropriate use of other soil samplers refer to D 6169.

1.3 This practice is often used in conjunction with fluid rotary drilling (D 1452, D 5783) or hollow-stem augers (D 6151). Subsurface geotechnical explorations should be reported in accordance with practice (D 5434). This practice discusses some aspects of sample preservation after the sampling event. For information on preservation and transportation process of soil samples, consult Practice D 4220. This practice does not address environmental sampling; consult D 6169 and D 6232for information on sampling for environmental investigations.

1.4 The values stated in inch-pound units are to be regarded as the standard. The SI values given in parentheses are provided for information purposes only. The tubing tolerances presented in Table 1 are from sources available in North America. Use of metric equivalent is acceptable as long as thickness and proportions are similar to those required in this standard.

1.5 *This standard does not purport to address all of the safety concerns, if any, associated with its use. It is the responsibility of the user of this standard to establish appropriate safety and health practices and determine the applicability of regulatory limitations prior to use.*

1.6 This practice offers a set of instructions for performing one or more specific operations. This document cannot replace education or experience and should be used in conjunction with professional judgment. Not all aspects of this practice may be applicable in all circumstances. This ASTM standard is not intended to represent or replace the standard of care by which the adequacy of a given professional service must be judged, nor should this document be applied without consideration of a project's many unique aspects. The word "Standard" in the title of this document means only that the document has been approved through the ASTM consensus process.

2. Referenced Documents

2.1 *ASTM Standards:* [2]

D 653 Terminology Relating to Soil, Rock, and Contained Fluids

D 1452 Practice for Soil Investigation and Sampling by Auger Borings

D 1586 Test Method for Penetration Test and Split-Barrel Sampling of Soils

D 2488 Practice for Description and Identification of Soils (Visual-Manual Procedure)

D 3550 Practice for Thick Wall, Ring-Lined, Split Barrel, Drive Sampling of Soils

D 3740 Practice for Minimum Requirements for Agencies Engaged in the Testing and/or Inspection of Soil and Rock

[1] This practice is under the jurisdiction of ASTM Committee D18 on Soil and Rock and is the direct responsibility of Subcommittee D18.02 on Sampling and Related Field Testing for Soil Evaluations.

Current edition approved May 1, 2007. Published July 2007. Originally approved in 1958. Last previous edition approved in 2003 as D 1587 – 03.

[2] For referenced ASTM standards, visit the ASTM website, www.astm.org, or contact ASTM Customer Service at service@astm.org. For *Annual Book of ASTM Standards* volume information, refer to the standard's Document Summary page on the ASTM website.

*A Summary of Changes section appears at the end of this standard.

TABLE 1 Dimensional Tolerances for Thin-Walled Tubes

	Nominal Tube Diameters from Table 2[A] Tolerances					
Size Outside Diameter	2 in.	50.8 mm	3 in.	76.2 mm	5 in.	127 mm
Outside diameter, D_o	+0.007 -0.000	+0.179 -0.000	+0.010 -0.000	+0.254 -0.000	+0.015 -0.000	0.381 -0.000
Inside diameter, D_i	+0.000 -0.007	+0.000 -0.179	+0.000 -0.010	+0.000 -0.254	+0.000 -0.015	+0.000 -0.381
Wall thickness	±0.007	±0.179	±0.010	±0.254	±0.015	±0.381
Ovality	0.015	0.381	0.020	0.508	0.030	0.762
Straightness	0.030/ft	2.50/m	0.030/ft	2.50/m	0.030/ft	2.50/m

[A] Intermediate or larger diameters should be proportional. Specify only two of the first three tolerances; that is, D_o and D_i, or D_o and Wall thickness, or D_i and Wall thickness.

as Used in Engineering Design and Construction

D 4220 Practices for Preserving and Transporting Soil Samples

D 5434 Guide for Field Logging of Subsurface Explorations of Soil and Rock

D 5783 Guide for Use of Direct Rotary Drilling with Water-Based Drilling Fluid for Geoenvironmental Exploration and the Installation of Subsurface Water-Quality Monitoring Devices

D 6151 Practice for Using Hollow-Stem Augers for Geotechnical Exploration and Soil Sampling

D 6169 Guide for Selection of Soil and Rock Sampling Devices Used With Drill Rigs for Environmental Investigations

D 6232 Guide for Selection of Sampling Equipment for Waste and Contaminated Media Data Collection Activities

3. Terminology

3.1 *Definitions:*

3.1.1 For common definitions of terms in this standard, refer to Terminology D 653.

3.2 *Definitions of Terms Specific to This Standard:*

3.2.1 *inside clearance ratio, %, n*—the ratio of the difference in the inside diameter of the tube, D_i, minus the inside diameter of the cutting edge, D_e, to the inside diameter of the tube, D_i expressed as a percentage (see Fig. 1).

3.2.2 *ovality, n*—the cross section of the tube that deviates from a perfect circle.

4. Summary of Practice

4.1 A relatively undisturbed sample is obtained by pressing a thin-walled metal tube into the in-situ soil at the bottom of a boring, removing the soil-filled tube, and applying seals to the soil surfaces to prevent soil movement and moisture gain or loss.

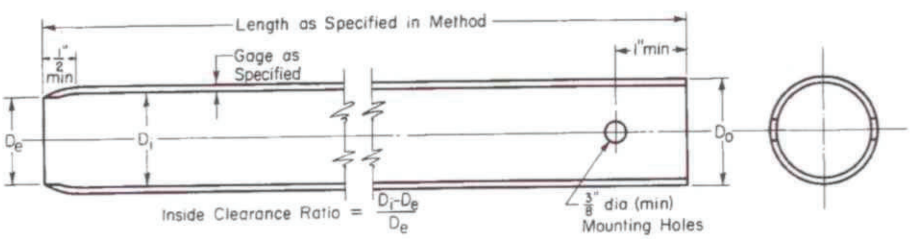
5. Significance and Use

5.1 This practice, or Practice D 3550 with thin wall shoe, is used when it is necessary to obtain a relatively undisturbed specimen suitable for laboratory tests of engineering properties or other tests that might be influenced by soil disturbance.

NOTE 2—The quality of the result produced by this standard is dependent on the competence of the personnel performing it, and the suitability of the equipment and facilities used. Agencies that meet the criteria of Practice D 3740 are generally considered capable of competent and objective sampling. Users of this practice are cautioned that compliance with Practice D 3740 does not in itself assure reliable results. Reliable results depend on many factors; Practice D 3740 provides a means of evaluating some of those factors.

6. Apparatus

6.1 *Drilling Equipment*—When sampling in a boring, any drilling equipment may be used that provides a reasonably



NOTE 1—Minimum of two mounting holes on opposite sides for D_o smaller than 4 in. (101.6 mm).

NOTE 2—Minimum of four mounting holes equally spaced for D_o 4 in. (101.6 mm) and larger.

NOTE 3—Tube held with hardened screws or other suitable means.

NOTE 4—2-in (50.8 mm) outside-diameter tubes are specified with an 18-gage wall thickness to comply with area ratio criteria accepted for "undisturbed samples." Users are advised that such tubing is difficult to locate and can be extremely expensive in small quantities. Sixteen-gage tubes are generally readily available.

Metric Equivalent Conversions

in.	mm
3/8	9.53
1/2	12.7
1	25.4
2	50.8
3	76.2
4	101.6
5	127

FIG. 1 Thin-Walled Tube for Sampling

TABLE 2 Suitable Thin-Walled Steel Sample Tubes[A]

Outside diameter (D_o):			
in.	2	3	5
mm	50.8	76.2	127
Wall thickness:			
Bwg	18	16	11
in.	0.049	0.065	0.120
mm	1.24	1.65	3.05
Tube length:			
in.	36	36	54
m	0.91	0.91	1.45
Inside clearance ratio, %	<1	<1	<1

[A] The three diameters recommended in Table 2 are indicated for purposes of standardization, and are not intended to indicate that sampling tubes of intermediate or larger diameters are not acceptable. Lengths of tubes shown are illustrative. Proper lengths to be determined as suited to field conditions.

clean hole; that minimizes disturbance of the soil to be sampled; and that does not hinder the penetration of the thin-walled sampler. Open borehole diameter and the inside diameter of driven casing or hollow stem auger shall not exceed 3.5 times the outside diameter of the thin-walled tube.

6.2 *Sampler Insertion Equipment*, shall be adequate to provide a relatively rapid continuous penetration force. For hard formations it may be necessary, although not recommended, to drive the thin-walled tube sampler.

6.3 *Thin-Walled Tubes*, should be manufactured to the dimensions as shown in Fig. 1. They should have an outside diameter of 2 to 5 in. (50 to 130 mm) and be made of metal having adequate strength for the type of soil to be sampled. Tubes shall be clean and free of all surface irregularities including projecting weld seams. Other diameters may be used but the tube dimensions should be proportional to the tube designs presented here.

6.3.1 *Length of Tubes*—See Table 2 and 7.4.1.

6.3.2 *Tolerances*, shall be within the limits shown in Table 1.

6.3.3 *Inside Clearance Ratio*, should be not greater than 1 % unless specified otherwise for the type of soil to be sampled. Generally, the inside clearance ratio used should increase with the increase in plasticity of the soil being sampled, except for sensitive soils or where local experience indicates otherwise. See 3.2.1 and Fig. 1 for definition of inside clearance ratio.

6.3.4 *Corrosion Protection*—Corrosion, whether from galvanic or chemical reaction, can damage or destroy both the thin-walled tube and the sample. Severity of damage is a function of time as well as interaction between the sample and the tube. Thin-walled tubes should have some form of protective coating, unless the soil is to be extruded less than 3 days. The type of coating to be used may vary depending upon the material to be sampled. Plating of the tubes or alternate base metals may be specified. Galvanized tubes are often used when long term storage is required. Coatings may include a light coat of lubricating oil, lacquer, epoxy, Teflon, zinc oxide, and others.

NOTE 3—Most coating materials are not resistant to scratching by soils that contain sands. Consideration should be given for prompt testing of the sample because chemical reactions between the metal and the soil sample con occur with time.

6.4 *Sampler Head*, serves to couple the thin-walled tube to the insertion equipment and, together with the thin-walled tube, comprises the thin-walled tube sampler. The sampler head shall contain a venting area and suitable check valve with the venting area to the outside equal to or greater than the area through the check valve. In some special cases, a check valve may not be required but venting is required to avoid sample compression. Attachment of the head to the tube shall be concentric and coaxial to assure uniform application of force to the tube by the sampler insertion equipment.

7. Procedure

7.1 Remove loose material from the center of a casing or hollow stem auger as carefully as possible to avoid disturbance of the material to be sampled. If groundwater is encountered, maintain the liquid level in the borehole at or above ground water level during the drilling and sampling operation.

7.2 Bottom discharge bits are not permitted. Side discharge bits may be used, with caution. Jetting through an open-tube sampler to clean out the borehole to sampling elevation is not permitted.

NOTE 4—Roller bits are available in downward-jetting and diffused-jet configurations. Downward-jetting configuration rock bits are not acceptable. Diffuse-jet configurations are generally acceptable.

7.3 Lower the sampling apparatus so that the sample tube's bottom rests on the bottom of the hole and record depth to the bottom of the sample tube to the nearest 0.1-ft (.03 m)

7.3.1 Keep the sampling apparatus plumb during lowering, thereby preventing the cutting edge of the tube from scraping the wall of the borehole.

7.4 Advance the sampler without rotation by a continuous relatively rapid downward motion and record length of advancement to the nearest 1 in. (25 mm).

7.4.1 Determine the length of advance by the resistance and condition of the soil formation, but the length shall never exceed 5 to 10 diameters of the tube in sands and 10 to 15 diameters of the tube in clays. In no case shall a length of advance be greater than the sample-tube length minus an allowance for the sampler head and a minimum of 3-in. (75 mm) for sludge and end cuttings.

NOTE 5—The mass of sample, laboratory handling capabilities, transportation problems, and commercial availability of tubes will generally limit maximum practical lengths to those shown in Table 2.

7.5 When the soil formation is too hard for push-type insertion, the tube may be driven or Practice D 3550 may be used. If driving methods are used, the data regarding weight and fall of the hammer and penetration achieved must be shown in the report. Additionally, that tube must be prominently labeled a "driven sample."

7.6 Withdraw the sampler from the soil formation as carefully as possible in order to minimize disturbance of the sample. The tube can be slowly rotated to shear the material at the end of the tube, and to relieve water and/or suction pressures and improve recovery. Where the soil formation is soft, a delay before withdraw of the sampler (typically 5 to 30 minutes) may improve sample recovery.

8. Sample Measurement, Sealing and Labeling

8.1 Upon removal of the tube, remove the drill cuttings in the upper end of the tube and measure the length of the soil sample recovered to the nearest 0.25 in. (5 mm) in the tube. Seal the upper end of the tube. Remove at least 1 in. (25 mm) of material from the lower end of the tube. Use this material for soil description in accordance with Practice D 2488. Measure the overall sample length. Seal the lower end of the tube. Alternatively, after measurement, the tube may be sealed without removal of soil from the ends of the tube.

8.1.1 Tubes sealed over the ends, as opposed to those sealed with expanding packers, should be provided with spacers or appropriate packing materials, or both prior to sealing the tube ends to provide proper confinement. Packing materials must be nonabsorbent and must maintain their properties to provide the same degree of sample support with time.

8.1.2 Depending on the requirements of the investigation, field extrusion and packaging of extruded soil samples can be performed. This allows for physical examination and classification of the sample. Samples are extruded in special hydraulic jacks equipped with properly sized platens to extrude the core in a continuous smooth speed. In some cases, further extrusion may cause sample disturbance reducing suitability for testing of engineering properties. In other cases, if damage is not significant, cores can be extruded and preserved for testing (D 4220). Bent or damaged tubes should be cut off before extruding.

8.2 Prepare and immediately affix labels or apply markings as necessary to identify the sample (see Section 9). Assure that the markings or labels are adequate to survive transportation and storage.

NOTE 6—Top end of the tube should be labeled "top".

9. Field Log

9.1 Record the information that may be required for preparing field logs in general accordance to ASTM D 5434 "Guide for Field Logging of Subsurface Explorations of Soil and Rock". This guide is used for logging explorations by drilling and sampling. Some examples of the information required include:

9.1.1 Name and location of the project,

9.1.2 Boring number,

9.1.3 Log of the soil conditions,

9.1.4 Surface elevation or reference to a datum to the nearest foot (0.5 m) or better,

9.1.5 Location of the boring,

9.1.6 Method of making the borehole,

9.1.7 Name of the drilling foreman and company, and

9.1.8 Name of the drilling inspector(s).

9.1.9 Date and time of boring-start and finish,

9.1.10 Depth to groundwater level: date and time measured,

9.2 Recording the appropriate sampling information is required as follows:

9.2.1 Depth to top of sample to the nearest 0.1 ft. (.03 m) and number of sample,

9.2.2 Description of thin-walled tube sampler: size, type of metal, type of coating,

9.2.3 Method of sampler insertion: push or drive,

9.2.4 Method of drilling, size of hole, casing, and drilling fluid used,

9.2.5 Soil description in accordance with Practice D 2488,

9.2.6 Length of sampler advance (push), and

9.2.7 Recovery: length of sample obtained.

10. Keywords

10.1 geologic investigations; sampling; soil exploration; soil investigations; subsurface investigations; undisturbed

SUMMARY OF CHANGES

In accordance with committee D18 policy, this section identifies the location of changes to this standard since the last edition, 200, which may impact the use of this standard.

(1) Added parts of speech to terms.

(2) Corrected reference in Note 2 from D 5740 to D 3740.

Logging of Soil Borings

I. Purpose and Scope

This SOP provides guidance to obtain accurate and consistent descriptions of soil characteristics during soil-sampling operations. The characterization is based on visual examination and manual tests, not on laboratory determinations.

II. Equipment and Materials

- Indelible pens
- Tape measure or ruler
- Field logbook
- Spatula
- HCL, 10 percent solution
- Squirt bottle with water
- Rock- or soil-color chart (e.g., Munsell)
- Grain-size chart
- Hand lens
- Unified Soil Classification System (USCS) index charts and tables to help with soil classification (attached)

III. Procedures and Guidelines

This section covers several aspects of soil characterization: instructions for completing the soil boring log form (attached), field classification of soil, and standard penetration test procedures.

A. Instructions for Completing Soil Boring Logs

Soil boring logs will be completed in the field log books or on separate soil boring log sheets. Information collected will be consistent with that required for ASTM D1586 (attached), a standard soil boring log form (attached), or an equivalent form that supplies the same information.

The information collected in the field to perform the soil characterization is described below.

Field personnel should review completed logs for accuracy, clarity, and thoroughness of detail. Samples also should be checked to see that information is correctly recorded on both sample jar labels and on the log sheets.

B. **Heading Information**

Boring/Well Number. Enter the boring/well number. A numbering system should be chosen that does not conflict with information recorded for previous exploratory work done at the site. Number the sheets consecutively for each boring.

Location. If station, coordinates, mileposts, or similar project layout information is available, indicate the position of the boring to that system using modifiers such as "approximate" or "estimated" as appropriate.

Elevation. Elevation will be determined at the conclusion of field activities through a survey.

Drilling Contractor. Enter the name of the drilling company and the city and state where the company is based.

Drilling Method and Equipment. Identify the bit size and type, drilling fluid (if used), and method of drilling (e.g., rotary, hollow-stem auger, sonic). Information on the drilling equipment (e.g., CME 55, Mobile B61) also is noted.

Water Level and Date. Enter the depth below ground surface to the apparent water level in the borehole. The information should be recorded as a comment. If free water is not encountered during drilling or cannot be detected because of the drilling method, this information should be noted. Record date and time of day (for tides, river stage) of each water level measurement.

Date of Start and Finish. Enter the dates the boring was begun and completed. Time of day should be added if several borings are performed on the same day.

Logger. Enter the first and last name.

C. **Technical Data**

Depth Below Surface. Use a depth scale that is appropriate for the sample spacing and for the complexity of subsurface conditions.

Sample Interval. Note the depth at the top and bottom of the sample interval.

Sample Type and Number. Enter the sample type and number. SS-1 = split spoon, first sample. Number samples consecutively regardless of type. Enter a sample number even if no material was recovered in the sampler.

Sample Recovery. Enter the length to the nearest 0.1-foot of soil sample recovered from the sampler. Often, there will be some wash or caved material above the sample; do not include the wash material in the measurement. Record soil recovery in feet.

Standard Penetration Test Results. In this column, enter the number of blows required for each 6 inches of sampler penetration and the "N" value, which is the sum of the blows in the middle two 6-inch penetration intervals. A typical standard penetration test involving successive blow counts of 2, 3, 4, and 5 is recorded as 2-3-4-5 and (7). The standard penetration test is terminated if the sampler encounters refusal. Refusal is a penetration of less than 6 inches with a blow count of 50. A partial penetration of 50 blows for 4 inches is recorded as 50/4 inches. Penetration by the weight of the slide hammer only is recorded as "WOH."

Samples should be collected using a 140-pound hammer and 2-inch diameter split spoons. Samples may be collected using direct push sampling equipment. However, blow counts will not be available. A pocket penetrometer may be used instead to determine relative soil consistency of fine grained materials (silts and clays).

Sample also may be collected using a 300-pound hammer or 3-inch-diameter split-spoon samples at the site. However, use of either of these sample collection devices invalidates standard penetration test results and should be noted in the comments section of the log. The 300-pound hammer should only be used for collection of 3-inch-diameter split-spoon samples. Blow counts should be recorded for collection of samples using either a 3-inch split-spoon, or a 300-pound hammer. An "N" value need not be calculated.

Soil Description. The soil classification should follow the format described in the "Field Classification of Soil" subsection below.

Comments. Include all pertinent observations (changes in drilling fluid color, rod drops, drilling chatter, rod bounce as in driving on a cobble, damaged Shelby tubes, and equipment malfunctions). In addition, note if casing was used, the sizes and depths installed, and if drilling fluid was added or changed. You should instruct the driller to alert you to any significant changes in drilling (changes in material, occurrence of boulders, and loss of drilling fluid). Such information should be attributed to the driller and recorded in this column.

Specific information might include the following:

- The date and the time drilling began and ended each day
- The depth and size of casing and the method of installation
- The date, time, and depth of water level measurements
- Depth of rod chatter
- Depth and percentage of drilling fluid loss
- Depth of hole caving or heaving
- Depth of change in material
- Health and safety monitoring data
- Drilling interval through a boulder

D. Field Classification of Soil

This section presents the format for the field classification of soil. In general, the approach and format for classifying soils should conform to ASTM D 2488, Visual-Manual Procedure for Description and Identification of Soils (attached).

The Unified Soil Classification System is based on numerical values of certain soil properties that are measured by laboratory tests. It is possible, however, to estimate these values in the field with reasonable accuracy using visual-manual procedures (ASTM D 2488). In addition, some elements of a complete soil description, such as the presence of cobbles or boulders, changes in strata, and the relative proportions of soil types in a bedded deposit, can be obtained only in the field.

Soil descriptions should be precise and comprehensive without being verbose. The correct overall impression of the soil should not be distorted by excessive emphasis on insignificant details. In general, similarities rather than differences between consecutive samples should be stressed.

Soil descriptions must be recorded for every soil sample collected. The format and order for soil descriptions should be as follows:

1. Soil name (synonymous with ASTM D 2488 Group Name) with appropriate modifiers. Soil name should be in all capitals in the log, for example "POORLY-GRADED SAND."
2. Group symbol, in parentheses, for example, "(SP)."
3. Color, using Munsell color designation
4. Moisture content
5. Relative density or consistency
6. Soil structure, mineralogy, or other descriptors

This order follows, in general, the format described in ASTM D 2488.

E. Soil Name

The basic name of a soil should be the ASTM D 2488 Group Name on the basis of visual estimates of gradation and plasticity. The soil name should be capitalized.

Examples of acceptable soil names are illustrated by the following descriptions:

- A soil sample is visually estimated to contain 15 percent gravel, 55 percent sand, and 30 percent fines (passing No. 200 sieve). The fines are estimated as either low or highly plastic silt. This visual classification is SILTY SAND WITH GRAVEL, with a Group Symbol of (SM).
- Another soil sample has the following visual estimate: 10 percent gravel, 30 percent sand, and 60 percent fines (passing the No. 200 sieve). The fines are estimated as low plastic silt. This visual classification is SANDY SILT. The gravel portion is not included in the soil name because the gravel portion was estimated as less than 15 percent. The Group Symbol is (ML).

The gradation of coarse-grained soil (more than 50 percent retained on No. 200 sieve) is included in the specific soil name in accordance with ASTM D 2488. There is no need to further document the gradation. However, the maximum size and angularity or roundness of gravel and sand-sized particles should be recorded. For fine-grained soil (50 percent or more passing the No. 200 sieve), the name is modified by the appropriate plasticity/elasticity term in accordance with ASTM D 2488.

Interlayered soil should each be described starting with the predominant type. An introductory name, such as "Interlayered Sand and Silt," should be used. In addition, the relative proportion of each soil type should be indicated (see Table 1 for example).

Where helpful, the evaluation of plasticity/elasticity can be justified by describing results from any of the visual-manual procedures for identifying fine-grained soils, such as reaction to shaking, toughness of a soil thread, or dry strength as described in ASTM D 2488.

F. Group Symbol

The appropriate group symbol from ASTM D 2488 must be given after each soil name. The group symbol should be placed in parentheses to indicate that the classification has been estimated.

In accordance with ASTM D 2488, dual symbols (e.g., GP-GM or SW-SC) can be used to indicate that a soil is estimated to have about 10 percent fines. Borderline symbols (e.g., GM/SM or SW/SP) can be used to indicate that a soil sample has been identified as having properties that do not distinctly place the soil into a specific group. Generally, the group name assigned to a soil with a borderline symbol should be the group name for the first symbol. The use of a borderline symbol should not be used indiscriminately. Every effort should be made to first place the soil into a single group.

G. Color

The color of a soil must be given. The color description should be based on the Munsell system. The color name and the hue, value, and chroma should be given.

H. Moisture Content

The degree of moisture present in a soil sample should be defined as dry, moist, or wet. Moisture content can be estimated from the criteria listed on Table 2.

I. Relative Density or Consistency

Relative density of a coarse-grained (cohesionless) soil is based on N-values (ASTM D 1586 [attached]). If the presence of large gravel, disturbance of the sample, or non-standard sample collection makes determination of the in situ relative density or consistency difficult, then this item should be left out of the description and explained in the Comments column of the soil boring log.

Consistency of fine-grained (cohesive) soil is properly based on results of pocket penetrometer or torvane results. In the absence of this information, consistency can be estimated from N-values. Relationships for determining relative density or consistency of soil samples are given in Tables 3 and 4.

J. Soil Structure, Mineralogy, and Other Descriptors

Discontinuities and inclusions are important and should be described. Such features include joints or fissures, slickensides, bedding or laminations, veins, root holes, and wood debris.

Significant mineralogical information such as cementation, abundant mica, or unusual mineralogy should be described.

Other descriptors may include particle size range or percentages, particle angularity or shape, maximum particle size, hardness of large particles, plasticity of fines, dry strength, dilatancy, toughness, reaction to HCl, and staining, as well as other information such as organic debris, odor, or presence of free product.

K. Equipment and Calibration

Before starting the testing, the equipment should be inspected for compliance with the requirements of ASTM D 1586. The split-barrel sampler should measure 2-inch or 3-inch OD, and should have a split tube at least 18 inches long. The minimum size sampler rod allowed is “A” rod (1-5/8-inch OD). A stiffer rod, such as an “N” rod (2-5/8-inch OD), is required for depths greater than 50 feet. The drive weight assembly should consist of a 140-pound or 300-pound hammer weight, a drive head, and a hammer guide that permits a free fall of 30 inches.

IV. Attachments

Soil Boring Log (Sample Soil Boring Log.xls)

Soil Boring Log Form with a completed example (Soil_Log_Examp.pdf)

ASTM D 2488 *Standard Practice for Description and Identification of Soils (Visual-Manual Procedures)* (ASTM D2488.pdf)

ASTM 1586 *Standard Test Method for Penetration Test and Split-Barrel Sampling of Soils* (ASTM D1586.pdf)

Tables 1 through 4 (Tables 1-4.pdf)

V. Key Checks and Preventive Maintenance

- Check entries to the soil-boring log and field logbook in the field; because the samples will be disposed of at the end of fieldwork, confirmation and corrections cannot be made later.
- Check that sample numbers and intervals are properly specified.
- Check that drilling and sampling equipment is decontaminated using the procedures defined in SOP *Decontamination of Drilling Rigs and Equipment*.

PROJECT NUMBER	BORING NUMBER SHEET OF
SOIL BORING LOG	

PROJECT ____________ LOCATION ____________

ELEVATION ____________ DRILLING CONTRACTOR ____________

DRILLING METHOD AND EQUIPMENT ____________

WATER LEVELS ____________ START ____________ FINISH ____________ LOGGER ____________

DEPTH BELOW SURFACE (FT)	SAMPLE			STANDARD PENETRATION TEST RESULTS	SOIL DESCRIPTION	COMMENTS
	INTERVAL	NUMBER AND TYPE	RECOVERY (FT)	6"-6"-6" (N)	SOIL NAME, USCS GROUP SYMBOL, COLOR, MOISTURE CONTENT, RELATIVE DENSITY OR CONSISTENCY, SOIL STRUCTURE, MINERALOGY	DEPTH OF CASING, DRILLING RATE, DRILLING FLUID LOSS, TESTS AND INSTRUMENTATION

Figure 1
SOIL BORING LOG, FORM D1586

CH2M HILL

PROJECT NUMBER	BORING NUMBER	SHEET 1 OF 3
DEN 22371.G5	BL-3	

SOIL BORING LOG

PROJECT Howard Ave Landslide LOCATION Howard & 24th Ave, Centennial, CO

ELEVATION 5136 Feet DRILLING CONTRACTOR Kendall Explorations, Ashcan, Colorado

DRILLING METHOD AND EQUIPMENT 4"-inch H.S. Augers, Mobil B-61 rotary drill rig

WATER LEVELS 3.2 Feet, 8/5/89 START August 4, 1989 FINISH August 8, 1989 LOGGER J.A. Michner

DEPTH BELOW SURFACE (FT)	SAMPLE INTERVAL	SAMPLE NUMBER AND TYPE	SAMPLE RECOVERY (FT)	STANDARD PENETRATION TEST RESULTS 6"-6"-6" (N)	SOIL DESCRIPTION: SOIL NAME, USCS GROUP SYMBOL, COLOR, MOISTURE CONTENT, RELATIVE DENSITY OR CONSISTENCY, SOIL STRUCTURE, MINERALOGY	COMMENTS: DEPTH OF CASING, DRILLING RATE, DRILLING FLUID LOSS, TESTS AND INSTRUMENTATION
0	2.5				Surface material consist of 4 inches AC underlain by 6 inches of 3/4 inch minus base rock	Start Drilling @ 3:00
	2.5–4.0	1-S	1.5	2-3-4 (7)	POORLY-GRADED SAND WITH SILT, (SP-SM), fine, light brown, wet, loose	Driller notes water at 4 feet
5	5.0–6.5	2-S	0.9	WOH/12"-1	ORGANIC SILT, (OL), very dark, gray to black, wet, very soft; strong H_2S odor, many fine roots up to about 1/4 inch	Driller notes very soft drilling 4ft. dark grey, wet silty cuttings.
	8.0–10.0	3-ST	1.3	—	ORGANIC SILT, similar to 2-S, except includes fewer roots (by volume)	
10	10.0–11.5	4-S	1.3	2-2-2 (4)	SILT, (ML), very dark gray to black, wet, soft	water level @ 3.2 feet on 8/5/89 @ 0730 Driller notes rough drilling action and chatter @ 13 ft
15	15.0–15.5	5-S	0.5	60/6"	SILTY GRAVEL, (GM), rounded gravel up to about 1 inch maximum observed size, wet, very dense	Driller notes smoother, firm drilling @ 19 ft
20	20.0–21.0	6-S	1.0	12-50/6"	LEAN CLAY WITH SAND, (CL), medium to light green, moist, very stiff	some angular rock chips @ bot tip of 6-S, poss boulders or rock Driller notes very hard, slow grinding, smooth drilling action from 21 to 23 ft, possibly bedrock
	23.0–23.1	7-S	0	50/1"	NO RECOVERY	
					END SOIL BORING @ 23.1 FEET SEE ROCK CORE LOG FOR CONTINUATION OF BL-3	

Figure 2
EXAMPLE OF COMPLETED LOG FORM

47 MAY 12 2003 EXAMPLE

0715 ARRIVE ON SITE AT XYZ SITE.
CH2M HILL STAFF:
John Smith: FIELD TEAM LEADER
Bob Builder: SITE SAFETY COORD.
WEATHER: OVERCAST + Cool, 45°F
CHANCE OF LATE SHOWERS
SCOPE: • Collect GROUNDWATER
SAMPLES for LTM work at SITE 14
• SUPERVISE SURVEY CREW
At SITE 17
0725 BB ~~Cal~~ JS Calibrates
PID: 101 ppm/100 ppm OK
PID Model #, SERIAL #
0730 BB Calibrates HORIBA METER
Model #, SERIAL #
→ List calibration Results
0738 Survey CREW ARRIVES on Site
→ List NAMES
0745 BB Holds H+S TAlk on Slips,
Trips, FAlls, Ticks + AIR Monitoring
JS + Survey CREW ATTEND
No H+S ISSUES IDENTIFIED as
concerns. All work is in "Level D."
0755 JS conducts site-wide Air Monitoring
All readings = 0.0 ppm in

JS
5-12-03

MAY 12, 2003 EXAMPLE 48

SITE 14 LTM
BREATHING ZONE (BZ)
0805 Mobilize to well MW-22 to
SAMPLE, surveyors setting up
At SITE 17
0815 PM (PAUL PAPER PUSHER) CAlls AND
INFORMS JS to collect GW SAMPLE
At well MW-44 today for 24 hour
TAT ANALYSIS OF VOC'S
0820 Purging MW-22
→ RECORD WATER QUALITY DATA

JS
5-12-03

0843 Collect SAMPLE At MW-22 for
total TAL Metals AND VOC'S. No
Dissolved Metals Needed per PM.
0905 JS + BB Mobilize to SITE 17 to
show surveyors wells to Survey.
0942 Mobilize to well MW-22 to
Collect SAMPLE...
0950 CAN not ACCESS well MW-22
due to BASE OPERATIONS; Contact
PAUL PAPER PUSHER AND he STATED
he will check on GAINING ACCESS
with BASE contact.
0955 Mobilize to well MW-19

JS
5-12-03

Designation: D 2488 – 00

Standard Practice for Description and Identification of Soils (Visual-Manual Procedure)[1]

This standard is issued under the fixed designation D 2488; the number immediately following the designation indicates the year of original adoption or, in the case of revision, the year of last revision. A number in parentheses indicates the year of last reapproval. A superscript epsilon (ε) indicates an editorial change since the last revision or reapproval.

This standard has been approved for use by agencies of the Department of Defense.

1. Scope *

1.1 This practice covers procedures for the description of soils for engineering purposes.

1.2 This practice also describes a procedure for identifying soils, at the option of the user, based on the classification system described in Test Method D 2487. The identification is based on visual examination and manual tests. It must be clearly stated in reporting an identification that it is based on visual-manual procedures.

1.2.1 When precise classification of soils for engineering purposes is required, the procedures prescribed in Test Method D 2487 shall be used.

1.2.2 In this practice, the identification portion assigning a group symbol and name is limited to soil particles smaller than 3 in. (75 mm).

1.2.3 The identification portion of this practice is limited to naturally occurring soils (disturbed and undisturbed).

NOTE 1—This practice may be used as a descriptive system applied to such materials as shale, claystone, shells, crushed rock, etc. (see Appendix X2).

1.3 The descriptive information in this practice may be used with other soil classification systems or for materials other than naturally occurring soils.

1.4 The values stated in inch-pound units are to be regarded as the standard.

1.5 *This standard does not purport to address all of the safety problems, if any, associated with its use. It is the responsibility of the user of this standard to establish appropriate safety and health practices and determine the applicability of regulatory limitations prior to use.* For specific precautionary statements see Section 8.

1.6 *This practice offers a set of instructions for performing one or more specific operations. This document cannot replace education or experience and should be used in conjunction with professional judgment. Not all aspects of this practice may be applicable in all circumstances. This ASTM standard is not intended to represent or replace the standard of care by which the adequacy of a given professional service must be judged, nor should this document be applied without consideration of a project's many unique aspects. The word "Standard" in the title of this document means only that the document has been approved through the ASTM consensus process.*

2. Referenced Documents

2.1 *ASTM Standards:*

D 653 Terminology Relating to Soil, Rock, and Contained Fluids[2]

D 1452 Practice for Soil Investigation and Sampling by Auger Borings[2]

D 1586 Test Method for Penetration Test and Split-Barrel Sampling of Soils[2]

D 1587 Practice for Thin-Walled Tube Sampling of Soils[2]

D 2113 Practice for Diamond Core Drilling for Site Investigation[2]

D 2487 Classification of Soils for Engineering Purposes (Unified Soil Classification System)[2]

D 3740 Practice for Minimum Requirements for Agencies Engaged in the Testing and/or Inspection of Soil and rock as Used in Engineering Design and Construction[3]

D 4083 Practice for Description of Frozen Soils (Visual-Manual Procedure)[2]

3. Terminology

3.1 *Definitions*—Except as listed below, all definitions are in accordance with Terminology D 653.

NOTE 2—For particles retained on a 3-in. (75-mm) US standard sieve, the following definitions are suggested:
Cobbles—particles of rock that will pass a 12-in. (300-mm) square opening and be retained on a 3-in. (75-mm) sieve, and
Boulders—particles of rock that will not pass a 12-in. (300-mm) square opening.

3.1.1 *clay*—soil passing a No. 200 (75-μm) sieve that can be made to exhibit plasticity (putty-like properties) within a range of water contents, and that exhibits considerable strength when air-dry. For classification, a clay is a fine-grained soil, or the fine-grained portion of a soil, with a plasticity index equal to or greater than 4, and the plot of plasticity index versus liquid

[1] This practice is under the jurisdiction of ASTM Committee D-18 on Soil and Rock and is the direct responsibility of Subcommittee D18.07 on Identification and Classification of Soils.

Current edition approved Feb. 10, 2000. Published May 2000. Originally published as D 2488 – 66 T. Last previous edition D 2488 – 93$^{\epsilon 1}$.

[2] *Annual Book of ASTM Standards*, Vol 04.08.

[3] *Annual Book of ASTM Standards*, Vol 04.09.

*A Summary of Changes section appears at the end of this standard.

limit falls on or above the "A" line (see Fig. 3 of Test Method D 2487).

3.1.2 *gravel*—particles of rock that will pass a 3-in. (75-mm) sieve and be retained on a No. 4 (4.75-mm) sieve with the following subdivisions:

coarse—passes a 3-in. (75-mm) sieve and is retained on a ¾-in. (19-mm) sieve.

fine—passes a ¾-in. (19-mm) sieve and is retained on a No. 4 (4.75-mm) sieve.

3.1.3 *organic clay*—a clay with sufficient organic content to influence the soil properties. For classification, an organic clay is a soil that would be classified as a clay, except that its liquid limit value after oven drying is less than 75 % of its liquid limit value before oven drying.

3.1.4 *organic silt*—a silt with sufficient organic content to influence the soil properties. For classification, an organic silt is a soil that would be classified as a silt except that its liquid limit value after oven drying is less than 75 % of its liquid limit value before oven drying.

3.1.5 *peat*—a soil composed primarily of vegetable tissue in various stages of decomposition usually with an organic odor, a dark brown to black color, a spongy consistency, and a texture ranging from fibrous to amorphous.

3.1.6 *sand*—particles of rock that will pass a No. 4 (4.75-mm) sieve and be retained on a No. 200 (75-μm) sieve with the following subdivisions:

coarse—passes a No. 4 (4.75-mm) sieve and is retained on a No. 10 (2.00-mm) sieve.

medium—passes a No. 10 (2.00-mm) sieve and is retained on a No. 40 (425-μm) sieve.

fine—passes a No. 40 (425-μm) sieve and is retained on a No. 200 (75-μm) sieve.

3.1.7 *silt*—soil passing a No. 200 (75-μm) sieve that is nonplastic or very slightly plastic and that exhibits little or no strength when air dry. For classification, a silt is a fine-grained soil, or the fine-grained portion of a soil, with a plasticity index less than 4, or the plot of plasticity index versus liquid limit falls below the "A" line (see Fig. 3 of Test Method D 2487).

4. Summary of Practice

4.1 Using visual examination and simple manual tests, this practice gives standardized criteria and procedures for describing and identifying soils.

4.2 The soil can be given an identification by assigning a group symbol(s) and name. The flow charts, Fig. 1a and Fig. 1b for fine-grained soils, and Fig. 2, for coarse-grained soils, can be used to assign the appropriate group symbol(s) and name. If the soil has properties which do not distinctly place it into a specific group, borderline symbols may be used, see Appendix X3.

NOTE 3—It is suggested that a distinction be made between *dual symbols* and *borderline symbols.*

Dual Symbol—A dual symbol is two symbols separated by a hyphen, for example, GP-GM, SW-SC, CL-ML used to indicate that the soil has been identified as having the properties of a classification in accordance with Test Method D 2487 where two symbols are required. Two symbols are required when the soil has between 5 and 12 % fines or when the liquid limit and plasticity index values plot in the CL-ML area of the plasticity chart.

Borderline Symbol—A borderline symbol is two symbols separated by a slash, for example, CL/CH, GM/SM, CL/ML. A borderline symbol should be used to indicate that the soil has been identified as having properties that do not distinctly place the soil into a specific group (see Appendix X3).

5. Significance and Use

5.1 The descriptive information required in this practice can be used to describe a soil to aid in the evaluation of its significant properties for engineering use.

5.2 The descriptive information required in this practice should be used to supplement the classification of a soil as determined by Test Method D 2487.

5.3 This practice may be used in identifying soils using the classification group symbols and names as prescribed in Test Method D 2487. Since the names and symbols used in this practice to identify the soils are the same as those used in Test Method D 2487, it shall be clearly stated in reports and all other appropriate documents, that the classification symbol and name are based on visual-manual procedures.

5.4 This practice is to be used not only for identification of soils in the field, but also in the office, laboratory, or wherever soil samples are inspected and described.

5.5 This practice has particular value in grouping similar soil samples so that only a minimum number of laboratory tests need be run for positive soil classification.

NOTE 4—The ability to describe and identify soils correctly is learned more readily under the guidance of experienced personnel, but it may also be acquired systematically by comparing numerical laboratory test results for typical soils of each type with their visual and manual characteristics.

5.6 When describing and identifying soil samples from a given boring, test pit, or group of borings or pits, it is not necessary to follow all of the procedures in this practice for every sample. Soils which appear to be similar can be grouped together; one sample completely described and identified with the others referred to as similar based on performing only a few of the descriptive and identification procedures described in this practice.

5.7 This practice may be used in combination with Practice D 4083 when working with frozen soils.

NOTE 5—Notwithstanding the statements on precision and bias contained in this standard: The precision of this test method is dependent on the competence of the personnel performing it and the suitability of the equipment and facilities used. Agencies that meet the criteria of Practice D 3740 are generally considered capable of competent and objective testing. Users of this test method are cautioned that compliance with Practice D 3740 does not in itself assure reliable testing. Reliable testing depends on several factors; Practice D 3740 provides a means for evaluating some of those factors.

6. Apparatus

6.1 *Required Apparatus*:

6.1.1 *Pocket Knife or Small Spatula*.

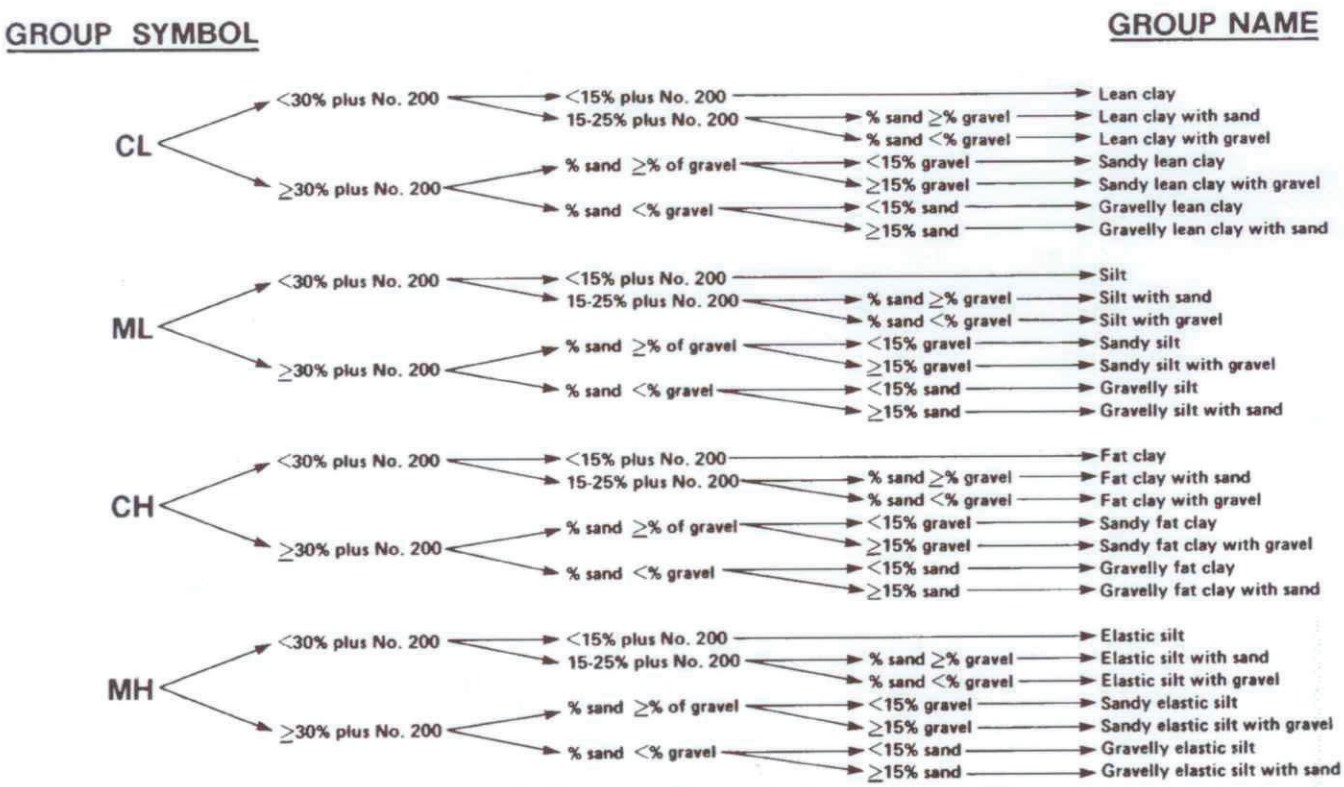
6.2 *Useful Auxiliary Apparatus*:

6.2.1 *Small Test Tube and Stopper* (or jar with a lid).

6.2.2 *Small Hand Lens*.

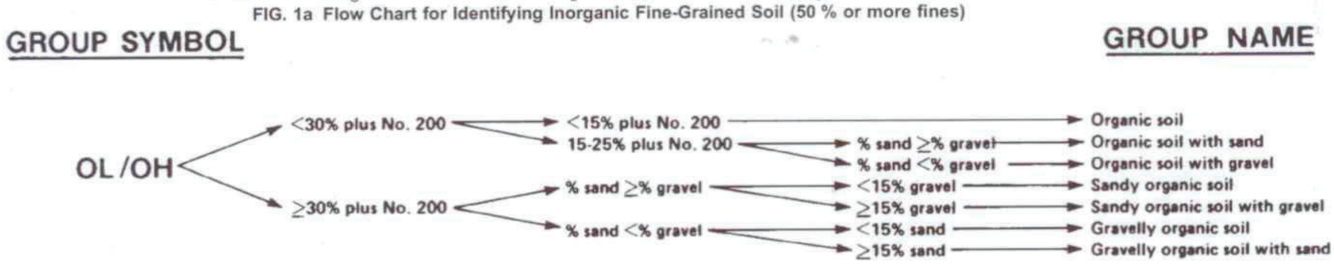
7. Reagents

7.1 *Purity of Water*—Unless otherwise indicated, references to water shall be understood to mean water from a city water



NOTE 1—Percentages are based on estimating amounts of fines, sand, and gravel to the nearest 5 %.

FIG. 1a Flow Chart for Identifying Inorganic Fine-Grained Soil (50 % or more fines)



NOTE 1—Percentages are based on estimating amounts of fines, sand, and gravel to the nearest 5 %.

FIG. 1 b Flow Chart for Identifying Organic Fine-Grained Soil (50 % or more fines)

supply or natural source, including non-potable water.

7.2 *Hydrochloric Acid*—A small bottle of dilute hydrochloric acid, HCl, one part HCl (10 *N*) to three parts water (This reagent is optional for use with this practice). See Section 8.

8. Safety Precautions

8.1 When preparing the dilute HCl solution of one part concentrated hydrochloric acid (10 *N*) to three parts of distilled water, slowly add acid into water following necessary safety precautions. Handle with caution and store safely. If solution comes into contact with the skin, rinse thoroughly with water.

8.2 **Caution**—Do not add water to acid.

9. Sampling

9.1 The sample shall be considered to be representative of the stratum from which it was obtained by an appropriate, accepted, or standard procedure.

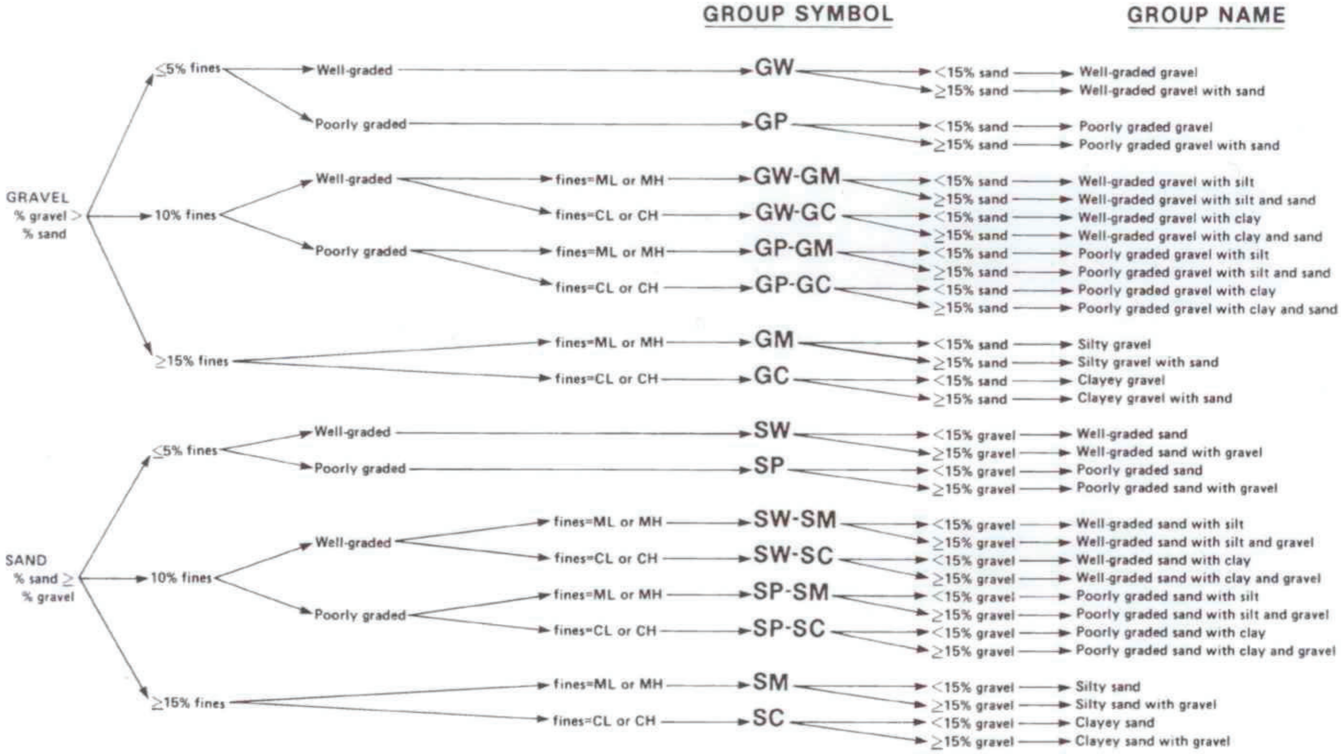
NOTE 6—Preferably, the sampling procedure should be identified as having been conducted in accordance with Practices D 1452, D 1587, or D 2113, or Test Method D 1586.

9.2 The sample shall be carefully identified as to origin.

NOTE 7—Remarks as to the origin may take the form of a boring number and sample number in conjunction with a job number, a geologic stratum, a pedologic horizon or a location description with respect to a permanent monument, a grid system or a station number and offset with respect to a stated centerline and a depth or elevation.

9.3 For accurate description and identification, the minimum amount of the specimen to be examined shall be in accordance with the following schedule:

Maximum Particle Size, Sieve Opening	Minimum Specimen Size, Dry Weight
4.75 mm (No. 4)	100 g (0.25 lb)
9.5 mm (⅜ in.)	200 g (0.5 lb)
19.0 mm (¾ in.)	1.0 kg (2.2 lb)
38.1 mm (1½ in.)	8.0 kg (18 lb)
75.0 mm (3 in.)	60.0 kg (132 lb)



NOTE 1—Percentages are based on estimating amounts of fines, sand, and gravel to the nearest 5 %.

FIG. 2 Flow Chart for Identifying Coarse-Grained Soils (less than 50 % fines)

NOTE 8—If random isolated particles are encountered that are significantly larger than the particles in the soil matrix, the soil matrix can be accurately described and identified in accordance with the preceeding schedule.

9.4 If the field sample or specimen being examined is smaller than the minimum recommended amount, the report shall include an appropriate remark.

10. Descriptive Information for Soils

10.1 *Angularity*—Describe the angularity of the sand (coarse sizes only), gravel, cobbles, and boulders, as angular, subangular, subrounded, or rounded in accordance with the criteria in Table 1 and Fig. 3. A range of angularity may be stated, such as: subrounded to rounded.

10.2 *Shape*—Describe the shape of the gravel, cobbles, and boulders as flat, elongated, or flat and elongated if they meet the criteria in Table 2 and Fig. 4. Otherwise, do not mention the shape. Indicate the fraction of the particles that have the shape, such as: one-third of the gravel particles are flat.

TABLE 1 Criteria for Describing Angularity of Coarse-Grained Particles (see Fig. 3)

Description	Criteria
Angular	Particles have sharp edges and relatively plane sides with unpolished surfaces
Subangular	Particles are similar to angular description but have rounded edges
Subrounded	Particles have nearly plane sides but have well-rounded corners and edges
Rounded	Particles have smoothly curved sides and no edges

10.3 *Color*—Describe the color. Color is an important property in identifying organic soils, and within a given locality it may also be useful in identifying materials of similar geologic origin. If the sample contains layers or patches of varying colors, this shall be noted and all representative colors shall be described. The color shall be described for moist samples. If the color represents a dry condition, this shall be stated in the report.

10.4 *Odor*—Describe the odor if organic or unusual. Soils containing a significant amount of organic material usually have a distinctive odor of decaying vegetation. This is especially apparent in fresh samples, but if the samples are dried, the odor may often be revived by heating a moistened sample. If the odor is unusual (petroleum product, chemical, and the like), it shall be described.

10.5 *Moisture Condition*—Describe the moisture condition as dry, moist, or wet, in accordance with the criteria in Table 3.

10.6 *HCl Reaction*—Describe the reaction with HCl as none, weak, or strong, in accordance with the critera in Table 4. Since calcium carbonate is a common cementing agent, a report of its presence on the basis of the reaction with dilute hydrochloric acid is important.

10.7 *Consistency*—For intact fine-grained soil, describe the consistency as very soft, soft, firm, hard, or very hard, in accordance with the criteria in Table 5. This observation is inappropriate for soils with significant amounts of gravel.

10.8 *Cementation*—Describe the cementation of intact coarse-grained soils as weak, moderate, or strong, in accordance with the criteria in Table 6.

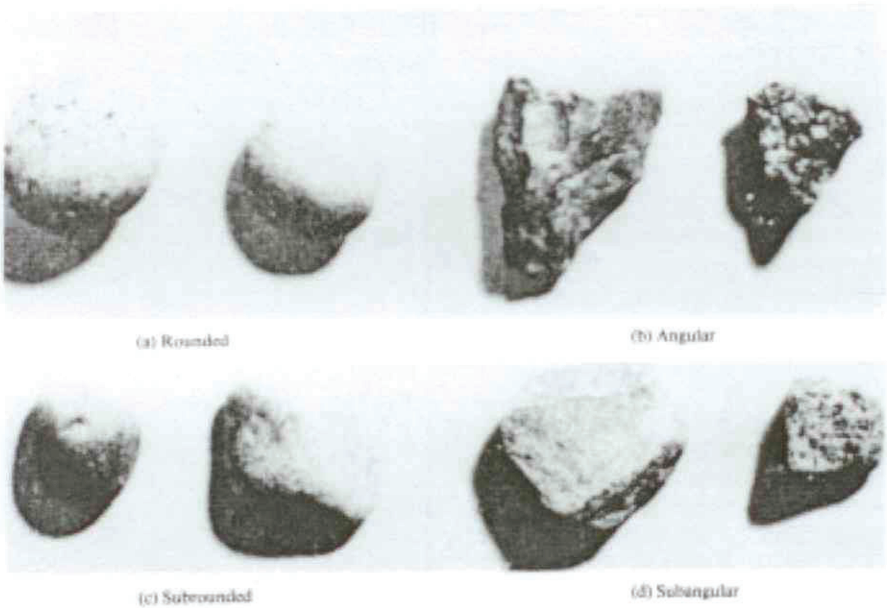


FIG. 3 Typical Angularity of Bulky Grains

TABLE 2 Criteria for Describing Particle Shape (see Fig. 4)

The particle shape shall be described as follows where length, width, and thickness refer to the greatest, intermediate, and least dimensions of a particle, respectively.

Flat	Particles with width/thickness > 3
Elongated	Particles with length/width > 3
Flat and elongated	Particles meet criteria for both flat and elongated

10.9 *Structure*—Describe the structure of intact soils in accordance with the criteria in Table 7.

10.10 *Range of Particle Sizes*—For gravel and sand components, describe the range of particle sizes within each component as defined in 3.1.2 and 3.1.6. For example, about 20 % fine to coarse gravel, about 40 % fine to coarse sand.

10.11 *Maximum Particle Size*—Describe the maximum particle size found in the sample in accordance with the following information:

10.11.1 *Sand Size*—If the maximum particle size is a sand size, describe as fine, medium, or coarse as defined in 3.1.6. For example: maximum particle size, medium sand.

10.11.2 *Gravel Size*—If the maximum particle size is a gravel size, describe the maximum particle size as the smallest sieve opening that the particle will pass. For example, maximum particle size, 1½ in. (will pass a 1½-in. square opening but not a ¾-in. square opening).

10.11.3 *Cobble or Boulder Size*—If the maximum particle size is a cobble or boulder size, describe the maximum dimension of the largest particle. For example: maximum dimension, 18 in. (450 mm).

10.12 *Hardness*—Describe the hardness of coarse sand and larger particles as hard, or state what happens when the particles are hit by a hammer, for example, gravel-size particles fracture with considerable hammer blow, some gravel-size particles crumble with hammer blow. "Hard" means particles do not crack, fracture, or crumble under a hammer blow.

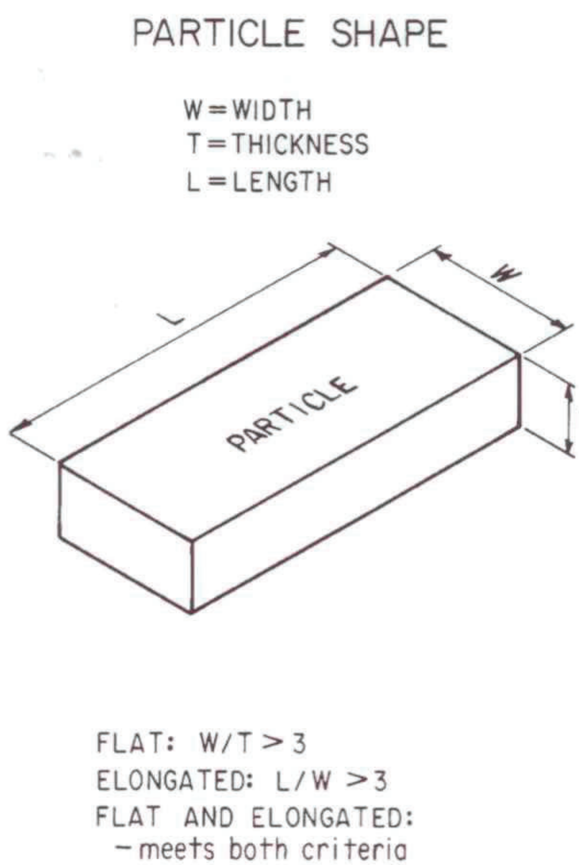


FIG. 4 Criteria for Particle Shape

10.13 Additional comments shall be noted, such as the presence of roots or root holes, difficulty in drilling or augering

TABLE 3 Criteria for Describing Moisture Condition

Description	Criteria
Dry	Absence of moisture, dusty, dry to the touch
Moist	Damp but no visible water
Wet	Visible free water, usually soil is below water table

TABLE 4 Criteria for Describing the Reaction With HCl

Description	Criteria
None	No visible reaction
Weak	Some reaction, with bubbles forming slowly
Strong	Violent reaction, with bubbles forming immediately

TABLE 5 Criteria for Describing Dilatancy

Description	Criteria
Very soft	Thumb will penetrate soil more than 1 in. (25 mm)
Soft	Thumb will penetrate soil about 1 in. (25 mm)
Firm	Thumb will indent soil about ¼in. (6 mm)
Hard	Thumb will not indent soil but readily indented with thumbnail
Very hard	Thumbnail will not indent soil

TABLE 6 Criteria for Describing Toughness

Description	Criteria
Weak	Crumbles or breaks with handling or little finger pressure
Moderate	Crumbles or breaks with considerable finger pressure
Strong	Will not crumble or break with finger pressure

TABLE 7 Criteria for Describing Dilatancy

Description	Criteria
Stratified	Alternating layers of varying material or color with layers at least 6 mm thick; note thickness
Laminated	Alternating layers of varying material or color with the layers less than 6 mm thick; note thickness
Fissured	Breaks along definite planes of fracture with little resistance to fracturing
Slickensided	Fracture planes appear polished or glossy, sometimes striated
Blocky	Cohesive soil that can be broken down into small angular lumps which resist further breakdown
Lensed	Inclusion of small pockets of different soils, such as small lenses of sand scattered through a mass of clay; note thickness
Homogeneous	Same color and appearance throughout

hole, caving of trench or hole, or the presence of mica.

10.14 A local or commercial name or a geologic interpretation of the soil, or both, may be added if identified as such.

10.15 A classification or identification of the soil in accordance with other classification systems may be added if identified as such.

11. Identification of Peat

11.1 A sample composed primarily of vegetable tissue in various stages of decomposition that has a fibrous to amorphous texture, usually a dark brown to black color, and an organic odor, shall be designated as a highly organic soil and shall be identified as peat, PT, and not subjected to the identification procedures described hereafter.

12. Preparation for Identification

12.1 The soil identification portion of this practice is based on the portion of the soil sample that will pass a 3-in. (75-mm) sieve. The larger than 3-in. (75-mm) particles must be removed, manually, for a loose sample, or mentally, for an intact sample before classifying the soil.

12.2 Estimate and note the percentage of cobbles and the percentage of boulders. Performed visually, these estimates will be on the basis of volume percentage.

NOTE 9—Since the percentages of the particle-size distribution in Test Method D 2487 are by dry weight, and the estimates of percentages for gravel, sand, and fines in this practice are by dry weight, it is recommended that the report state that the percentages of cobbles and boulders are by volume.

12.3 Of the fraction of the soil smaller than 3 in. (75 mm), estimate and note the percentage, by dry weight, of the gravel, sand, and fines (see Appendix X4 for suggested procedures).

NOTE 10—Since the particle-size components appear visually on the basis of volume, considerable experience is required to estimate the percentages on the basis of dry weight. Frequent comparisons with laboratory particle-size analyses should be made.

12.3.1 The percentages shall be estimated to the closest 5 %. The percentages of gravel, sand, and fines must add up to 100 %.

12.3.2 If one of the components is present but not in sufficient quantity to be considered 5 % of the smaller than 3-in. (75-mm) portion, indicate its presence by the term *trace*, for example, trace of fines. A trace is not to be considered in the total of 100 % for the components.

13. Preliminary Identification

13.1 The soil is *fine grained* if it contains 50 % or more fines. Follow the procedures for identifying fine-grained soils of Section 14.

13.2 The soil is *coarse grained* if it contains less than 50 % fines. Follow the procedures for identifying coarse-grained soils of Section 15.

14. Procedure for Identifying Fine-Grained Soils

14.1 Select a representative sample of the material for examination. Remove particles larger than the No. 40 sieve (medium sand and larger) until a specimen equivalent to about a handful of material is available. Use this specimen for performing the dry strength, dilatancy, and toughness tests.

14.2 *Dry Strength*:

14.2.1 From the specimen, select enough material to mold into a ball about 1 in. (25 mm) in diameter. Mold the material until it has the consistency of putty, adding water if necessary.

14.2.2 From the molded material, make at least three test specimens. A test specimen shall be a ball of material about ½ in. (12 mm) in diameter. Allow the test specimens to dry in air, or sun, or by artificial means, as long as the temperature does not exceed 60°C.

14.2.3 If the test specimen contains natural dry lumps, those that are about ½ in. (12 mm) in diameter may be used in place of the molded balls.

NOTE 11—The process of molding and drying usually produces higher strengths than are found in natural dry lumps of soil.

14.2.4 Test the strength of the dry balls or lumps by crushing between the fingers. Note the strength as none, low, medium, high, or very high in accorance with the criteria in Table 8. If natural dry lumps are used, do not use the results of any of the lumps that are found to contain particles of coarse sand.

14.2.5 The presence of high-strength water-soluble cementing materials, such as calcium carbonate, may cause exceptionally high dry strengths. The presence of calcium carbonate can usually be detected from the intensity of the reaction with dilute hydrochloric acid (see 10.6).

14.3 *Dilatancy*:

14.3.1 From the specimen, select enough material to mold into a ball about ½ in. (12 mm) in diameter. Mold the material, adding water if necessary, until it has a soft, but not sticky, consistency.

14.3.2 Smooth the soil ball in the palm of one hand with the blade of a knife or small spatula. Shake horizontally, striking the side of the hand vigorously against the other hand several times. Note the reaction of water appearing on the surface of the soil. Squeeze the sample by closing the hand or pinching the soil between the fingers, and note the reaction as none, slow, or rapid in accordance with the criteria in Table 9. The reaction is the speed with which water appears while shaking, and disappears while squeezing.

14.4 *Toughness*:

14.4.1 Following the completion of the dilatancy test, the test specimen is shaped into an elongated pat and rolled by hand on a smooth surface or between the palms into a thread about ⅛ in. (3 mm) in diameter. (If the sample is too wet to roll easily, it should be spread into a thin layer and allowed to lose some water by evaporation.) Fold the sample threads and reroll repeatedly until the thread crumbles at a diameter of about ⅛ in. The thread will crumble at a diameter of ⅛ in. when the soil is near the plastic limit. Note the pressure required to roll the thread near the plastic limit. Also, note the strength of the thread. After the thread crumbles, the pieces should be lumped together and kneaded until the lump crumbles. Note the toughness of the material during kneading.

14.4.2 Describe the toughness of the thread and lump as low, medium, or high in accordance with the criteria in Table 10.

14.5 *Plasticity*—On the basis of observations made during the toughness test, describe the plasticity of the material in accordance with the criteria given in Table 11.

14.6 Decide whether the soil is an *inorganic* or an *organic* fine-grained soil (see 14.8). If inorganic, follow the steps given in 14.7.

TABLE 8 Criteria for Describing Toughness

Description	Criteria
None	The dry specimen crumbles into powder with mere pressure of handling
Low	The dry specimen crumbles into powder with some finger pressure
Medium	The dry specimen breaks into pieces or crumbles with considerable finger pressure
High	The dry specimen cannot be broken with finger pressure. Specimen will break into pieces between thumb and a hard surface
Very high	The dry specimen cannot be broken between the thumb and a hard surface

TABLE 9 Criteria for Describing Dilatancy

Description	Criteria
None	No visible change in the specimen
Slow	Water appears slowly on the surface of the specimen during shaking and does not disappear or disappears slowly upon squeezing
Rapid	Water appears quickly on the surface of the specimen during shaking and disappears quickly upon squeezing

TABLE 10 Criteria for Describing Toughness

Description	Criteria
Low	Only slight pressure is required to roll the thread near the plastic limit. The thread and the lump are weak and soft
Medium	Medium pressure is required to roll the thread to near the plastic limit. The thread and the lump have medium stiffness
High	Considerable pressure is required to roll the thread to near the plastic limit. The thread and the lump have very high stiffness

TABLE 11 Criteria for Describing Plasticity

Description	Criteria
Nonplastic	A ⅛-in. (3-mm) thread cannot be rolled at any water content
Low	The thread can barely be rolled and the lump cannot be formed when drier than the plastic limit
Medium	The thread is easy to roll and not much time is required to reach the plastic limit. The thread cannot be rerolled after reaching the plastic limit. The lump crumbles when drier than the plastic limit
High	It takes considerable time rolling and kneading to reach the plastic limit. The thread can be rerolled several times after reaching the plastic limit. The lump can be formed without crumbling when drier than the plastic limit

14.7 *Identification of Inorganic Fine-Grained Soils*:

14.7.1 Identify the soil as a *lean clay*, CL, if the soil has medium to high dry strength, no or slow dilatancy, and medium toughness and plasticity (see Table 12).

14.7.2 Identify the soil as a *fat clay*, CH, if the soil has high to very high dry strength, no dilatancy, and high toughness and plasticity (see Table 12).

14.7.3 Identify the soil as a *silt*, ML, if the soil has no to low dry strength, slow to rapid dilatancy, and low toughness and plasticity, or is nonplastic (see Table 12).

14.7.4 Identify the soil as an *elastic silt*, MH, if the soil has low to medium dry strength, no to slow dilatancy, and low to medium toughness and plasticity (see Table 12).

NOTE 12—These properties are similar to those for a lean clay. However, the silt will dry quickly on the hand and have a smooth, silky feel when dry. Some soils that would classify as MH in accordance with the criteria in Test Method D 2487 are visually difficult to distinguish from lean clays, CL. It may be necessary to perform laboratory testing for proper identification.

TABLE 12 Identification of Inorganic Fine-Grained Soils from Manual Tests

Soil Symbol	Dry Strength	Dilatancy	Toughness
ML	None to low	Slow to rapid	Low or thread cannot be formed
CL	Medium to high	None to slow	Medium
MH	Low to medium	None to slow	Low to medium
CH	High to very high	None	High

14.8 *Identification of Organic Fine-Grained Soils*:

14.8.1 Identify the soil as an *organic soil*, OL/OH, if the soil contains enough organic particles to influence the soil properties. Organic soils usually have a dark brown to black color and may have an organic odor. Often, organic soils will change color, for example, black to brown, when exposed to the air. Some organic soils will lighten in color significantly when air dried. Organic soils normally will not have a high toughness or plasticity. The thread for the toughness test will be spongy.

NOTE 13—In some cases, through practice and experience, it may be possible to further identify the organic soils as organic silts or organic clays, OL or OH. Correlations between the dilatancy, dry strength, toughness tests, and laboratory tests can be made to identify organic soils in certain deposits of similar materials of known geologic origin.

14.9 If the soil is estimated to have 15 to 25 % sand or gravel, or both, the words "with sand" or "with gravel" (whichever is more predominant) shall be added to the group name. For example: "lean clay with sand, CL" or "silt with gravel, ML" (see Fig. 1a and Fig. 1b). If the percentage of sand is equal to the percentage of gravel, use "with sand."

14.10 If the soil is estimated to have 30 % or more sand or gravel, or both, the words "sandy" or "gravelly" shall be added to the group name. Add the word "sandy" if there appears to be more sand than gravel. Add the word "gravelly" if there appears to be more gravel than sand. For example: "sandy lean clay, CL", "gravelly fat clay, CH", or "sandy silt, ML" (see Fig. 1a and Fig. 1b). If the percentage of sand is equal to the percent of gravel, use "sandy."

15. Procedure for Identifying Coarse-Grained Soils

(Contains less than 50 % fines)

15.1 The soil is a *gravel* if the percentage of gravel is estimated to be more than the percentage of sand.

15.2 The soil is a *sand* if the percentage of gravel is estimated to be equal to or less than the percentage of sand.

15.3 The soil is a *clean gravel* or *clean sand* if the percentage of fines is estimated to be 5 % or less.

15.3.1 Identify the soil as a *well-graded gravel*, GW, or as a *well-graded sand*, SW, if it has a wide range of particle sizes and substantial amounts of the intermediate particle sizes.

15.3.2 Identify the soil as a *poorly graded gravel*, GP, or as a *poorly graded sand*, SP, if it consists predominantly of one size (uniformly graded), or it has a wide range of sizes with some intermediate sizes obviously missing (gap or skip graded).

15.4 The soil is either a *gravel with fines* or a *sand with fines* if the percentage of fines is estimated to be 15 % or more.

15.4.1 Identify the soil as a *clayey gravel*, GC, or a *clayey sand*, SC, if the fines are clayey as determined by the procedures in Section 14.

15.4.2 Identify the soil as a *silty gravel*, GM, or a *silty sand*, SM, if the fines are silty as determined by the procedures in Section 14.

15.5 If the soil is estimated to contain 10 % fines, give the soil a dual identification using two group symbols.

15.5.1 The first group symbol shall correspond to a clean gravel or sand (GW, GP, SW, SP) and the second symbol shall correspond to a gravel or sand with fines (GC, GM, SC, SM).

15.5.2 The group name shall correspond to the first group symbol plus the words "with clay" or "with silt" to indicate the plasticity characteristics of the fines. For example: "well-graded gravel with clay, GW-GC" or "poorly graded sand with silt, SP-SM" (see Fig. 2).

15.6 If the specimen is predominantly sand or gravel but contains an estimated 15 % or more of the other coarse-grained constituent, the words "with gravel" or "with sand" shall be added to the group name. For example: "poorly graded gravel with sand, GP" or "clayey sand with gravel, SC" (see Fig. 2).

15.7 If the field sample contains any cobbles or boulders, or both, the words "with cobbles" or "with cobbles and boulders" shall be added to the group name. For example: "silty gravel with cobbles, GM."

16. Report

16.1 The report shall include the information as to origin, and the items indicated in Table 13.

NOTE 14—*Example: Clayey Gravel with Sand and Cobbles, GC*—About 50 % fine to coarse, subrounded to subangular gravel; about 30 % fine to coarse, subrounded sand; about 20 % fines with medium plasticity, high dry strength, no dilatancy, medium toughness; weak reaction with HCl; original field sample had about 5 % (by volume) subrounded cobbles, maximum dimension, 150 mm.

In-Place Conditions—Firm, homogeneous, dry, brown

Geologic Interpretation—Alluvial fan

NOTE 15—Other examples of soil descriptions and identification are given in Appendix X1 and Appendix X2.

NOTE 16—If desired, the percentages of gravel, sand, and fines may be stated in terms indicating a range of percentages, as follows:

Trace—Particles are present but estimated to be less than 5 %

Few—5 to 10 %

Little—15 to 25 %

Some—30 to 45 %

Mostly—50 to 100 %

TABLE 13 Checklist for Description of Soils

1. Group name
2. Group symbol
3. Percent of cobbles or boulders, or both (by volume)
4. Percent of gravel, sand, or fines, or all three (by dry weight)
5. Particle-size range:
   Gravel—fine, coarse
   Sand—fine, medium, coarse
6. Particle angularity: angular, subangular, subrounded, rounded
7. Particle shape: (if appropriate) flat, elongated, flat and elongated
8. Maximum particle size or dimension
9. Hardness of coarse sand and larger particles
10. Plasticity of fines: nonplastic, low, medium, high
11. Dry strength: none, low, medium, high, very high
12. Dilatancy: none, slow, rapid
13. Toughness: low, medium, high
14. Color (in moist condition)
15. Odor (mention only if organic or unusual)
16. Moisture: dry, moist, wet
17. Reaction with HCl: none, weak, strong

For intact samples:

18. Consistency (fine-grained soils only): very soft, soft, firm, hard, very hard
19. Structure: stratified, laminated, fissured, slickensided, lensed, homogeneous
20. Cementation: weak, moderate, strong
21. Local name
22. Geologic interpretation
23. Additional comments: presence of roots or root holes, presence of mica, gypsum, etc., surface coatings on coarse-grained particles, caving or sloughing of auger hole or trench sides, difficulty in augering or excavating, etc.

16.2 If, in the soil description, the soil is identified using a classification group symbol and name as described in Test Method D 2487, it must be distinctly and clearly stated in log forms, summary tables, reports, and the like, that the symbol and name are based on visual-manual procedures.

17. Precision and Bias

17.1 This practice provides qualitative information only, therefore, a precision and bias statement is not applicable.

18. Keywords

18.1 classification; clay; gravel; organic soils; sand; silt; soil classification; soil description; visual classification

APPENDIXES

(Nonmandatory Information)

X1. EXAMPLES OF VISUAL SOIL DESCRIPTIONS

X1.1 The following examples show how the information required in 16.1 can be reported. The information that is included in descriptions should be based on individual circumstances and need.

X1.1.1 *Well-Graded Gravel with Sand (GW)*—About 75 % fine to coarse, hard, subangular gravel; about 25 % fine to coarse, hard, subangular sand; trace of fines; maximum size, 75 mm, brown, dry; no reaction with HCl.

X1.1.2 *Silty Sand with Gravel (SM)*—About 60 % predominantly fine sand; about 25 % silty fines with low plasticity, low dry strength, rapid dilatancy, and low toughness; about 15 % fine, hard, subrounded gravel, a few gravel-size particles fractured with hammer blow; maximum size, 25 mm; no reaction with HCl (Note—Field sample size smaller than recommended).

In-Place Conditions—Firm, stratified and contains lenses of silt 1 to 2 in. (25 to 50 mm) thick, moist, brown to gray; in-place density 106 lb/ft^3; in-place moisture 9 %.

X1.1.3 *Organic Soil (OL/OH)*—About 100 % fines with low plasticity, slow dilatancy, low dry strength, and low toughness; wet, dark brown, organic odor; weak reaction with HCl.

X1.1.4 *Silty Sand with Organic Fines (SM)*—About 75 % fine to coarse, hard, subangular reddish sand; about 25 % organic and silty dark brown nonplastic fines with no dry strength and slow dilatancy; wet; maximum size, coarse sand; weak reaction with HCl.

X1.1.5 *Poorly Graded Gravel with Silt, Sand, Cobbles and Boulders (GP-GM)*—About 75 % fine to coarse, hard, subrounded to subangular gravel; about 15 % fine, hard, subrounded to subangular sand; about 10 % silty nonplastic fines; moist, brown; no reaction with HCl; original field sample had about 5 % (by volume) hard, subrounded cobbles and a trace of hard, subrounded boulders, with a maximum dimension of 18 in. (450 mm).

X2. USING THE IDENTIFICATION PROCEDURE AS A DESCRIPTIVE SYSTEM FOR SHALE, CLAYSTONE, SHELLS, SLAG, CRUSHED ROCK, AND THE LIKE

X2.1 The identification procedure may be used as a descriptive system applied to materials that exist in-situ as shale, claystone, sandstone, siltstone, mudstone, etc., but convert to soils after field or laboratory processing (crushing, slaking, and the like).

X2.2 Materials such as shells, crushed rock, slag, and the like, should be identified as such. However, the procedures used in this practice for describing the particle size and plasticity characteristics may be used in the description of the material. If desired, an identification using a group name and symbol according to this practice may be assigned to aid in describing the material.

X2.3 The group symbol(s) and group names should be placed in quotation marks or noted with some type of distinguishing symbol. See examples.

X2.4 Examples of how group names and symbols can be incororated into a descriptive system for materials that are not naturally occurring soils are as follows:

X2.4.1 *Shale Chunks*—Retrieved as 2 to 4-in. (50 to 100-mm) pieces of shale from power auger hole, dry, brown, no reaction with HCl. After slaking in water for 24 h, material identified as "Sandy Lean Clay (CL)"; about 60 % fines with medium plasticity, high dry strength, no dilatancy, and medium toughness; about 35 % fine to medium, hard sand; about 5 % gravel-size pieces of shale.

X2.4.2 *Crushed Sandstone*—Product of commercial crushing operation; "Poorly Graded Sand with Silt (SP-SM)"; about 90 % fine to medium sand; about 10 % nonplastic fines; dry, reddish-brown, strong reaction with HCl.

X2.4.3 *Broken Shells*—About 60 % gravel-size broken shells; about 30 % sand and sand-size shell pieces; about 10 % fines; "Poorly Graded Gravel with Sand (GP)."

X2.4.4 *Crushed Rock*—Processed from gravel and cobbles in Pit No. 7; "Poorly Graded Gravel (GP)"; about 90 % fine, hard, angular gravel-size particles; about 10 % coarse, hard, angular sand-size particles; dry, tan; no reaction with HCl.

X3. SUGGESTED PROCEDURE FOR USING A BORDERLINE SYMBOL FOR SOILS WITH TWO POSSIBLE IDENTIFICATIONS.

X3.1 Since this practice is based on estimates of particle size distribution and plasticity characteristics, it may be difficult to clearly identify the soil as belonging to one category. To indicate that the soil may fall into one of two possible basic groups, a borderline symbol may be used with the two symbols separated by a slash. For example: SC/CL or CL/CH.

X3.1.1 A borderline symbol may be used when the percentage of fines is estimated to be between 45 and 55 %. One symbol should be for a coarse-grained soil with fines and the other for a fine-grained soil. For example: GM/ML or CL/SC.

X3.1.2 A borderline symbol may be used when the percentage of sand and the percentage of gravel are estimated to be about the same. For example: GP/SP, SC/GC, GM/SM. It is practically impossible to have a soil that would have a borderline symbol of GW/SW.

X3.1.3 A borderline symbol may be used when the soil could be either well graded or poorly graded. For example: GW/GP, SW/SP.

X3.1.4 A borderline symbol may be used when the soil could either be a silt or a clay. For example: CL/ML, CH/MH, SC/SM.

X3.1.5 A borderline symbol may be used when a fine-grained soil has properties that indicate that it is at the boundary between a soil of low compressibility and a soil of high compressibility. For example: CL/CH, MH/ML.

X3.2 The order of the borderline symbols should reflect similarity to surrounding or adjacent soils. For example: soils in a borrow area have been identified as CH. One sample is considered to have a borderline symbol of CL and CH. To show similarity, the borderline symbol should be CH/CL.

X3.3 The group name for a soil with a borderline symbol should be the group name for the first symbol, except for:

CL/CH lean to fat clay
ML/CL clayey silt
CL/ML silty clay

X3.4 The use of a borderline symbol should not be used indiscriminately. Every effort shall be made to first place the soil into a single group.

X4. SUGGESTED PROCEDURES FOR ESTIMATING THE PERCENTAGES OF GRAVEL, SAND, AND FINES IN A SOIL SAMPLE

X4.1 *Jar Method*—The relative percentage of coarse- and fine-grained material may be estimated by thoroughly shaking a mixture of soil and water in a test tube or jar, and then allowing the mixture to settle. The coarse particles will fall to the bottom and successively finer particles will be deposited with increasing time; the sand sizes will fall out of suspension in 20 to 30 s. The relative proportions can be estimated from the relative volume of each size separate. This method should be correlated to particle-size laboratory determinations.

X4.2 *Visual Method*—Mentally visualize the gravel size particles placed in a sack (or other container) or sacks. Then, do the same with the sand size particles and the fines. Then, mentally compare the number of sacks to estimate the percentage of plus No. 4 sieve size and minus No. 4 sieve size present. The percentages of sand and fines in the minus sieve size No. 4 material can then be estimated from the wash test (X4.3).

X4.3 *Wash Test (for relative percentages of sand and fines)*—Select and moisten enough minus No. 4 sieve size material to form a 1-in (25-mm) cube of soil. Cut the cube in half, set one-half to the side, and place the other half in a small dish. Wash and decant the fines out of the material in the dish until the wash water is clear and then compare the two samples and estimate the percentage of sand and fines. Remember that the percentage is based on weight, not volume. However, the volume comparison will provide a reasonable indication of grain size percentages.

X4.3.1 While washing, it may be necessary to break down lumps of fines with the finger to get the correct percentages.

X5. ABBREVIATED SOIL CLASSIFICATION SYMBOLS

X5.1 In some cases, because of lack of space, an abbreviated system may be useful to indicate the soil classification symbol and name. Examples of such cases would be graphical logs, databases, tables, etc.

X5.2 This abbreviated system is not a substitute for the full name and descriptive information but can be used in supplementary presentations when the complete description is referenced.

X5.3 The abbreviated system should consist of the soil classification symbol based on this standard with appropriate lower case letter prefixes and suffixes as:

Prefix: Suffix:

s = sandy	s = with sand
g = gravelly	g = with gravel
	c = with cobbles
	b = with boulders

X5.4 The soil classification symbol is to be enclosed in parenthesis. Some examples would be:

Group Symbol and Full Name	Abbreviated
CL, Sandy lean clay	s(CL)
SP-SM, Poorly graded sand with silt and gravel	(SP-SM)g
GP, poorly graded gravel with sand, cobbles, and boulders	(GP)scb
ML, gravelly silt with sand and cobbles	g(ML)sc

SUMMARY OF CHANGES

In accordance with Committee D18 policy, this section identifies the location of changes to this standard since the last edition ($1993^{\epsilon 1}$) that may impact the use of this standard.

(1) Added Practice D 3740 to Section 2.

(2) Added Note 5 under 5.7 and renumbered subsequent notes.

Designation: D 1586 – 08

Standard Test Method for Standard Penetration Test (SPT) and Split-Barrel Sampling of Soils[1]

This standard is issued under the fixed designation D 1586; the number immediately following the designation indicates the year of original adoption or, in the case of revision, the year of last revision. A number in parentheses indicates the year of last reapproval. A superscript epsilon (ε) indicates an editorial change since the last revision or reapproval.

This standard has been approved for use by agencies of the Department of Defense.

1. Scope*

1.1 This test method describes the procedure, generally known as the Standard Penetration Test (SPT), for driving a split-barrel sampler to obtain a representative disturbed soil sample for identification purposes, and measure the resistance of the soil to penetration of the sampler. Another method (Test Method D 3550) to drive a split-barrel sampler to obtain a representative soil sample is available but the hammer energy is not standardized.

1.2 Practice D 6066 gives a guide to determining the normalized penetration resistance of sands for energy adjustments of N-value to a constant energy level for evaluating liquefaction potential.

1.3 Test results and identification information are used to estimate subsurface conditions for foundation design.

1.4 Penetration resistance testing is typically performed at 5-foot depth intervals or when a significant change of materials is observed during drilling, unless otherwise specified.

1.5 This test method is limited to use in nonlithified soils and soils whose maximum particle size is approximately less than one-half of the sampler diameter.

1.6 This test method involves use of rotary drilling equipment (Guide D 5783, Practice D 6151). Other drilling and sampling procedures (Guide D 6286, Guide D 6169) are available and may be more appropriate. Considerations for hand driving or shallow sampling without boreholes are not addressed. Subsurface investigations should be recorded in accordance with Practice D 5434. Samples should be preserved and transported in accordance with Practice D 4220 using Group B. Soil samples should be identified by group name and symbol in accordance with Practice D 2488.

1.7 All observed and calculated values shall conform to the guidelines for significant digits and rounding established in Practice D 6026, unless superseded by this test method.

1.8 The values stated in inch-pound units are to be regarded as standard, except as noted below. The values given in parentheses are mathematical conversions to SI units, which are provided for information only and are not considered standard.

1.8.1 The gravitational system of inch-pound units is used when dealing with inch-pound units. In this system, the pound (lbf) represents a unit of force (weight), while the unit for mass is slugs.

1.9 Penetration resistance measurements often will involve safety planning, administration, and documentation. This test method does not purport to address all aspects of exploration and site safety. *This standard does not purport to address all of the safety concerns, if any, associated with its use. It is the responsibility of the user of this standard to establish appropriate safety and health practices and determine the applicability of regulatory limitations prior to use.* Performance of the test usually involves use of a drill rig; therefore, safety requirements as outlined in applicable safety standards (for example, OSHA regulations,[2] NDA Drilling Safety Guide,[3] drilling safety manuals, and other applicable state and local regulations) must be observed.

2. Referenced Documents

2.1 *ASTM Standards:* [4]

D 653 Terminology Relating to Soil, Rock, and Contained Fluids

D 854 Test Methods for Specific Gravity of Soil Solids by Water Pycnometer

D 1587 Practice for Thin-Walled Tube Sampling of Soils for Geotechnical Purposes

D 2216 Test Methods for Laboratory Determination of Water (Moisture) Content of Soil and Rock by Mass

D 2487 Practice for Classification of Soils for Engineering Purposes (Unified Soil Classification System)

D 2488 Practice for Description and Identification of Soils

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[1] This method is under the jurisdiction of ASTM Committee D18 on Soil and Rock and is the direct responsibility of Subcommittee D18.02 on Sampling and Related Field Testing for Soil Evaluations.

Current edition approved Feb. 1, 2008. Published March 2008. Originally approved in 1958. Last previous edition approved in 1999 as D 1586 – 99.

[2] Available from Occupational Safety and Health Administration (OSHA), 200 Constitution Ave., NW, Washington, DC 20210, http://www.osha.gov.

[3] Available from the National Drilling Association, 3511 Center Rd., Suite 8, Brunswick, OH 44212, http://www.nda4u.com.

[4] For referenced ASTM standards, visit the ASTM website, www.astm.org, or contact ASTM Customer Service at service@astm.org. For *Annual Book of ASTM Standards* volume information, refer to the standard's Document Summary page on the ASTM website.

***A Summary of Changes section appears at the end of this standard.**

(Visual-Manual Procedure)

D 3550 Practice for Thick Wall, Ring-Lined, Split Barrel, Drive Sampling of Soils

D 3740 Practice for Minimum Requirements for Agencies Engaged in the Testing and/or Inspection of Soil and Rock as Used in Engineering Design and Construction

D 4220 Practices for Preserving and Transporting Soil Samples

D 4633 Test Method for Energy Measurement for Dynamic Penetrometers

D 5434 Guide for Field Logging of Subsurface Explorations of Soil and Rock

D 5783 Guide for Use of Direct Rotary Drilling with Water-Based Drilling Fluid for Geoenvironmental Exploration and the Installation of Subsurface Water-Quality Monitoring Devices

D 6026 Practice for Using Significant Digits in Geotechnical Data

D 6066 Practice for Determining the Normalized Penetration Resistance of Sands for Evaluation of Liquefaction Potential

D 6151 Practice for Using Hollow-Stem Augers for Geotechnical Exploration and Soil Sampling

D 6169 Guide for Selection of Soil and Rock Sampling Devices Used With Drill Rigs for Environmental Investigations

D 6286 Guide for Selection of Drilling Methods for Environmental Site Characterization

D 6913 Test Methods for Particle-Size Distribution (Gradation) of Soils Using Sieve Analysis

3. Terminology

3.1 *Definitions:* Definitions of terms included in Terminology D 653 specific to this practice are:

3.1.1 *cathead, n*—the rotating drum or windlass in the rope-cathead lift system around which the operator wraps a rope to lift and drop the hammer by successively tightening and loosening the rope turns around the drum.

3.1.2 *drill rods, n*—rods used to transmit downward force and torque to the drill bit while drilling a borehole.

3.1.3 *N-value, n*—the blow count representation of the penetration resistance of the soil. The *N*-value, reported in blows per foot, equals the sum of the number of blows (*N*) required to drive the sampler over the depth interval of 6 to 18 in. (150 to 450 mm) (see 7.3).

3.1.4 *Standard Penetration Test (SPT), n*—a test process in the bottom of the borehole where a split-barrel sampler having an inside diameter of either 1-1/2-in. (38.1 mm) or 1-3/8-in. (34.9 mm) (see Note 2) is driven a given distance of 1.0 ft (0.30 m) after a seating interval of 0.5 ft (0.15 m) using a hammer weighing approximately 140-lbf (623-N) falling 30 ± 1.0 in. (0.76 m ± 0.030 m) for each hammer blow.

3.2 *Definitions of Terms Specific to This Standard:*

3.2.1 *anvil, n*—that portion of the drive-weight assembly which the hammer strikes and through which the hammer energy passes into the drill rods.

3.2.2 *drive weight assembly, n*—an assembly that consists of the hammer, anvil, hammer fall guide system, drill rod attachment system, and any hammer drop system hoisting attachments.

3.2.3 *hammer, n*—that portion of the drive-weight assembly consisting of the 140 ± 2 lbf (623 ± 9 N) impact weight which is successively lifted and dropped to provide the energy that accomplishes the sampling and penetration.

3.2.4 *hammer drop system, n*—that portion of the drive-weight assembly by which the operator or automatic system accomplishes the lifting and dropping of the hammer to produce the blow.

3.2.5 *hammer fall guide, n*—that part of the drive-weight assembly used to guide the fall of the hammer.

3.2.6 *number of rope turns, n*—the total contact angle between the rope and the cathead at the beginning of the operator's rope slackening to drop the hammer, divided by 360° (see Fig. 1).

3.2.7 *sampling rods, n*—rods that connect the drive-weight assembly to the sampler. Drill rods are often used for this purpose.

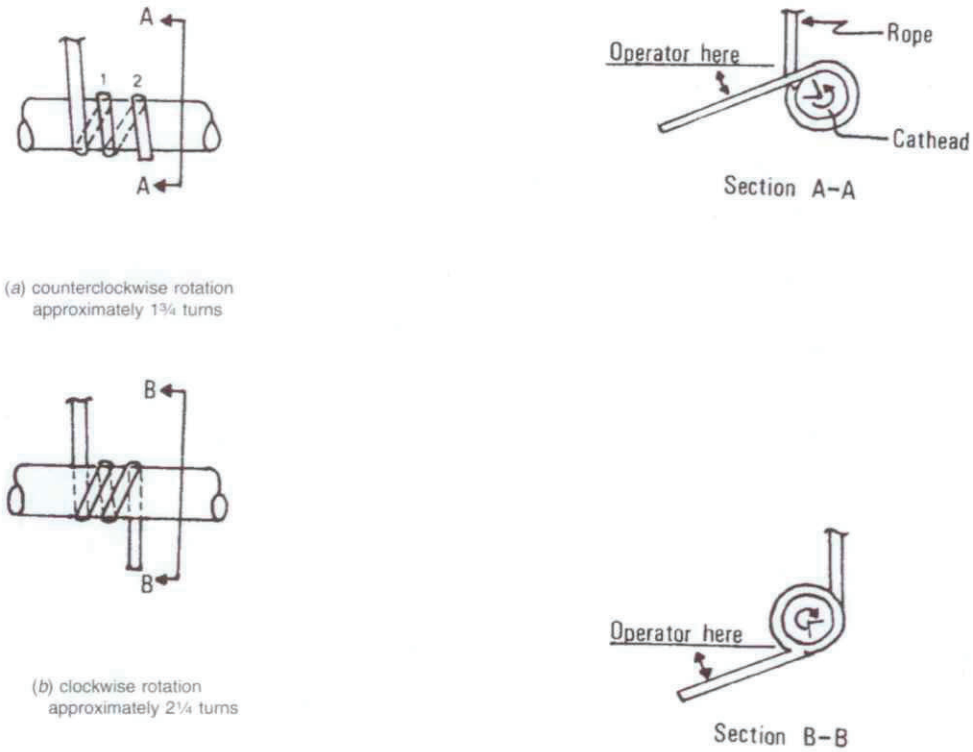
4. Significance and Use

4.1 This test method provides a disturbed soil sample for moisture content determination, for identification and classification (Practices D 2487 and D 2488) purposes, and for laboratory tests appropriate for soil obtained from a sampler that will produce large shear strain disturbance in the sample such as Test Methods D 854, D 2216, and D 6913. Soil deposits containing gravels, cobbles, or boulders typically result in penetration refusal and damage to the equipment.

4.2 This test method provides a disturbed soil sample for moisture content determination and laboratory identification. Sample quality is generally not suitable for advanced laboratory testing for engineering properties. The process of driving the sampler will cause disturbance of the soil and change the engineering properties. Use of the thin wall tube sampler (Practice D 1587) may result in less disturbance in soft soils. Coring techniques may result in less disturbance than SPT sampling for harder soils, but it is not always the case, that is, some cemented soils may become loosened by water action during coring; see Practice D 6151, and Guide D 6169.

4.3 This test method is used extensively in a great variety of geotechnical exploration projects. Many local correlations and widely published correlations which relate blow count, or *N*-value, and the engineering behavior of earthworks and foundations are available. For evaluating the liquefaction potential of sands during an earthquake event, the *N*-value should be normalized to a standard overburden stress level. Practice D 6066 provides methods to obtain a record of normalized resistance of sands to the penetration of a standard sampler driven by a standard energy. The penetration resistance is adjusted to drill rod energy ratio of 60 % by using a hammer system with either an estimated energy delivery or directly measuring drill rod stress wave energy using Test Method D 4633.

NOTE 1—The reliability of data and interpretations generated by this practice is dependent on the competence of the personnel performing it



(*a*) counterclockwise rotation approximately 1¾ turns

(*b*) clockwise rotation approximately 2¼ turns

FIG. 1 Definitions of the Number of Rope Turns and the Angle for (*a*) Counterclockwise Rotation and (*b*) Clockwise Rotation of the Cathead

and the suitability of the equipment and facilities used. Agencies that meet the criteria of Practice D 3740 generally are considered capable of competent testing. Users of this practice are cautioned that compliance with Practice D 3740 does not assure reliable testing. Reliable testing depends on several factors and Practice D 3740 provides a means of evaluating some of these factors. Practice D 3740 was developed for agencies engaged in the testing, inspection, or both, of soils and rock. As such, it is not totally applicable to agencies performing this practice. Users of this test method should recognize that the framework of Practice D 3740 is appropriate for evaluating the quality of an agency performing this test method. Currently, there is no known qualifying national authority that inspects agencies that perform this test method.

5. Apparatus

5.1 *Drilling Equipment*—Any drilling equipment that provides at the time of sampling a suitable borehole before insertion of the sampler and ensures that the penetration test is performed on undisturbed soil shall be acceptable. The following pieces of equipment have proven to be suitable for advancing a borehole in some subsurface conditions:

5.1.1 *Drag, Chopping, and Fishtail Bits*, less than 6½ in. (165 mm) and greater than 2¼ in. (57 mm) in diameter may be used in conjunction with open-hole rotary drilling or casing-advancement drilling methods. To avoid disturbance of the underlying soil, bottom discharge bits are not permitted; only side discharge bits are permitted.

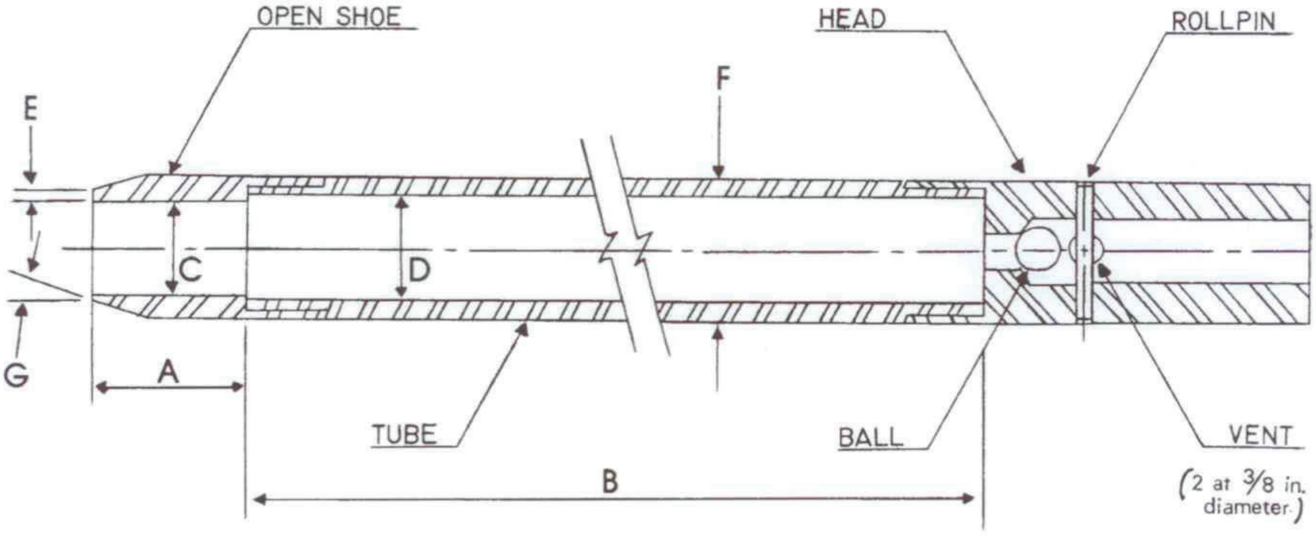
5.1.2 *Roller-Cone Bits*, less than 6½ in. (165 mm) and greater than 2¼ in. (57 mm) in diameter may be used in conjunction with open-hole rotary drilling or casing-advancement drilling methods if the drilling fluid discharge is deflected.

5.1.3 *Hollow-Stem Continuous Flight Augers*, with or without a center bit assembly, may be used to drill the borehole. The inside diameter of the hollow-stem augers shall be less than 6½ in. (165 mm) and not less than 2¼ in. (57 mm).

5.1.4 *Solid, Continuous Flight, Bucket and Hand Augers*, less than 6½ in. (165 mm) and not less than 2¼ in. (57 mm) in diameter may be used if the soil on the side of the borehole does not cave onto the sampler or sampling rods during sampling.

5.2 *Sampling Rods*—Flush-joint steel drill rods shall be used to connect the split-barrel sampler to the drive-weight assembly. The sampling rod shall have a stiffness (moment of inertia) equal to or greater than that of parallel wall "A" rod (a steel rod that has an outside diameter of 1-5/8 in. (41.3 mm) and an inside diameter of 1-1/8 in. (28.5 mm).

5.3 *Split-Barrel Sampler*—The standard sampler dimensions are shown in Fig. 2. The sampler has an outside diameter of 2.00 in. (50.8 mm). The inside diameter of the of the split-barrel (dimension D in Fig. 2) can be either 1½-in. (38.1



A = 1.0 to 2.0 in. (25 to 50 mm)
B = 18.0 to 30.0 in. (0.457 to 0.762 m)
C = 1.375 ± 0.005 in. (34.93 ± 0.13 mm)
D = 1.50 ± 0.05 – 0.00 in. (38.1 ± 1.3 – 0.0 mm)
E = 0.10 ± 0.02 in. (2.54 ± 0.25 mm)
F = 2.00 ± 0.05 – 0.00 in. (50.8 ± 1.3 – 0.0 mm)
G = 16.0° to 23.0°

FIG. 2 Split-Barrel Sampler

mm) or 1⅜-in. (34.9 mm) (see Note 2). A 16-gauge liner can be used inside the 1½-in. (38.1 mm) split barrel sampler. The driving shoe shall be of hardened steel and shall be replaced or repaired when it becomes dented or distorted. The penetrating end of the drive shoe may be slightly rounded. The split-barrel sampler must be equipped with a ball check and vent. Metal or plastic baskets may be used to retain soil samples.

NOTE 2—Both theory and available test data suggest that *N*-values may differ as much as 10 to 30 % between a constant inside diameter sampler and upset wall sampler. If it is necessary to correct for the upset wall sampler refer to Practice D 6066. In North America, it is now common practice to use an upset wall sampler with an inside diameter of 1½ in. At one time, liners were used but practice evolved to use the upset wall sampler without liners. Use of an upset wall sampler allows for use of retainers if needed, reduces inside friction, and improves recovery. Many other countries still use a constant ID split-barrel sampler, which was the original standard and still acceptable within this standard.

5.4 *Drive-Weight Assembly*:

5.4.1 *Hammer and Anvil*—The hammer shall weigh 140 ± 2 lbf (623 ± 9 N) and shall be a rigid metallic mass. The hammer shall strike the anvil and make steel on steel contact when it is dropped. A hammer fall guide permitting an unimpeded fall shall be used. Fig. 3 shows a schematic of such hammers. Hammers used with the cathead and rope method shall have an unimpeded over lift capacity of at least 4 in. (100 mm). For safety reasons, the use of a hammer assembly with an internal anvil is encouraged as shown in Fig. 3. The total mass of the hammer assembly bearing on the drill rods should not be more than 250 ± 10 lbm (113 ± 5 kg).

NOTE 3—It is suggested that the hammer fall guide be permanently marked to enable the operator or inspector to judge the hammer drop height.

5.4.2 *Hammer Drop System*—Rope-cathead, trip, semi-automatic or automatic hammer drop systems, as shown in Fig. 4 may be used, providing the lifting apparatus will not cause penetration of the sampler while re-engaging and lifting the hammer.

5.5 *Accessory Equipment*—Accessories such as labels, sample containers, data sheets, and groundwater level measuring devices shall be provided in accordance with the requirements of the project and other ASTM standards.

6. Drilling Procedure

6.1 The borehole shall be advanced incrementally to permit intermittent or continuous sampling. Test intervals and locations are normally stipulated by the project engineer or geologist. Typically, the intervals selected are 5 ft (1.5 m) or less in homogeneous strata with test and sampling locations at every change of strata. Record the depth of drilling to the nearest 0.1 ft (0.030 m).

6.2 Any drilling procedure that provides a suitably clean and stable borehole before insertion of the sampler and assures that the penetration test is performed on essentially undisturbed soil shall be acceptable. Each of the following procedures has proven to be acceptable for some subsurface conditions. The subsurface conditions anticipated should be considered when selecting the drilling method to be used.

6.2.1 Open-hole rotary drilling method.

6.2.2 Continuous flight hollow-stem auger method.

6.2.3 Wash boring method.

6.2.4 Continuous flight solid auger method.

6.3 Several drilling methods produce unacceptable boreholes. The process of jetting through an open tube sampler and

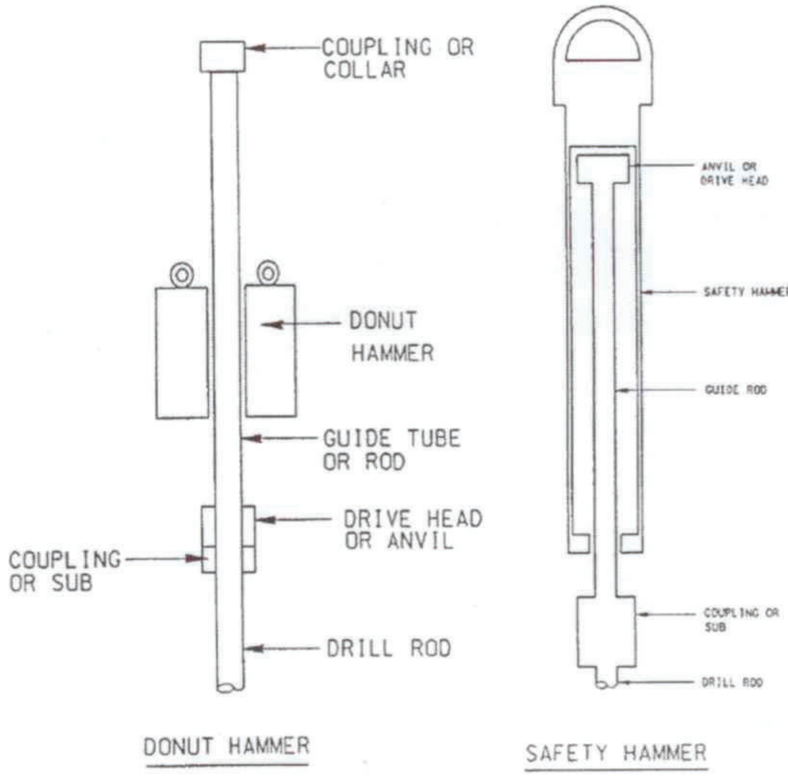


FIG. 3 Schematic Drawing of the Donut Hammer and Safety Hammer

then sampling when the desired depth is reached shall not be permitted. The continuous flight solid auger method shall not be used for advancing the borehole below a water table or below the upper confining bed of a confined non-cohesive stratum that is under artesian pressure. Casing may not be advanced below the sampling elevation prior to sampling. Advancing a borehole with bottom discharge bits is not permissible. It is not permissible to advance the borehole for subsequent insertion of the sampler solely by means of previous sampling with the SPT sampler.

6.4 The drilling fluid level within the borehole or hollow-stem augers shall be maintained at or above the in situ groundwater level at all times during drilling, removal of drill rods, and sampling.

7. Sampling and Testing Procedure

7.1 After the borehole has been advanced to the desired sampling elevation and excessive cuttings have been removed, record the cleanout depth to the nearest 0.1 ft (0.030 m), and prepare for the test with the following sequence of operations:

7.1.1 Attach either split-barrel sampler Type A or B to the sampling rods and lower into the borehole. Do not allow the sampler to drop onto the soil to be sampled.

7.1.2 Position the hammer above and attach the anvil to the top of the sampling rods. This may be done before the sampling rods and sampler are lowered into the borehole.

7.1.3 Rest the dead weight of the sampler, rods, anvil, and drive weight on the bottom of the borehole. Record the sampling start depth to the nearest 0.1 ft (0.030 m). Compare the sampling start depth to the cleanout depth in 7.1. If excessive cuttings are encountered at the bottom of the borehole, remove the sampler and sampling rods from the borehole and remove the cuttings.

7.1.4 Mark the drill rods in three successive 0.5-foot (0.15 m) increments so that the advance of the sampler under the impact of the hammer can be easily observed for each 0.5-foot (0.15 m) increment.

7.2 Drive the sampler with blows from the 140-lbf (623-N) hammer and count the number of blows applied in each 0.5-foot (0.15-m) increment until one of the following occurs:

7.2.1 A total of 50 blows have been applied during any one of the three 0.5-foot (0.15-m) increments described in 7.1.4.

7.2.2 A total of 100 blows have been applied.

7.2.3 There is no observed advance of the sampler during the application of 10 successive blows of the hammer.

7.2.4 The sampler is advanced the complete 1.5 ft. (0.45 m) without the limiting blow counts occurring as described in 7.2.1, 7.2.2, or 7.2.3.

7.2.5 If the sampler sinks under the weight of the hammer, weight of rods, or both, record the length of travel to the nearest 0.1 ft (0.030 m), and drive the sampler through the remainder of the test interval. If the sampler sinks the complete interval, stop the penetration, remove the sampler and sampling rods from the borehole, and advance the borehole through the very soft or very loose materials to the next desired sampling elevation. Record the *N*-value as either weight of hammer, weight of rods, or both.

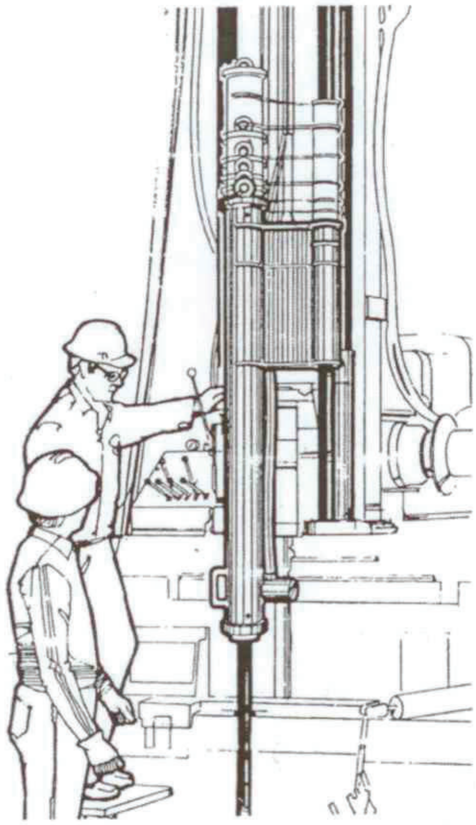


FIG. 4 Automatic Trip Hammer

7.3 Record the number of blows (*N*) required to advance the sampler each 0.5-foot (0.15 m) of penetration or fraction thereof. The first 0.5-foot (0.15 m) is considered to be a seating drive. The sum of the number of blows required for the second and third 0.5-foot (0.15 m) of penetration is termed the "standard penetration resistance," or the "*N*-value." If the sampler is driven less than 1.5 ft (0.45 m), as permitted in 7.2.1, 7.2.2, or 7.2.3, the number of blows per each complete 0.5-foot (0.15 m) increment and per each partial increment shall be recorded on the boring log. For partial increments, the depth of penetration shall be reported to the nearest 0.1 ft (0.030 m) in addition to the number of blows. If the sampler advances below the bottom of the borehole under the static weight of the drill rods or the weight of the drill rods plus the static weight of the hammer, this information should be noted on the boring log.

7.4 The raising and dropping of the 140-lbf (623-N) hammer shall be accomplished using either of the following two methods. Energy delivered to the drill rod by either method can be measured according to procedures in Test Method D 4633.

7.4.1 *Method A*—By using a trip, automatic, or semi-automatic hammer drop system that lifts the 140-lbf (623-N) hammer and allows it to drop 30 ± 1.0 in. (0.76 m ± 0.030 m) with limited unimpedence. Drop heights adjustments for automatic and trip hammers should be checked daily and at first indication of variations in performance. Operation of automatic hammers shall be in strict accordance with operations manuals.

7.4.2 *Method B*—By using a cathead to pull a rope attached to the hammer. When the cathead and rope method is used the system and operation shall conform to the following:

7.4.2.1 The cathead shall be essentially free of rust, oil, or grease and have a diameter in the range of 6 to 10 in. (150 to 250 mm).

7.4.2.2 The cathead should be operated at a minimum speed of rotation of 100 RPM.

7.4.2.3 The operator should generally use either 1-3/4 or 2-1/4 rope turns on the cathead, depending upon whether or not the rope comes off the top (1-3/4 turns for counterclockwise rotation) or the bottom (2-1/4 turns for clockwise rotation) of the cathead during the performance of the penetration test, as shown in Fig. 1. It is generally known and accepted that 2-3/4 or more rope turns considerably impedes the fall of the hammer and should not be used to perform the test. The cathead rope should be stiff, relatively dry, clean, and should be replaced when it becomes excessively frayed, oily, limp, or burned.

7.4.2.4 For each hammer blow, a 30 ± 1.0 in. (0.76 m ± 0.030 m) lift and drop shall be employed by the operator. The operation of pulling and throwing the rope shall be performed rhythmically without holding the rope at the top of the stroke.

NOTE 4—If the hammer drop height is something other than 30 ± 1.0 in. (0.76 m ± 0.030 m), then record the new drop height. For soils other than sands, there is no known data or research that relates to adjusting the *N*-value obtained from different drop heights. Test method D 4633 provides information on making energy measurement for variable drop heights and Practice D 6066 provides information on adjustment of *N*-value to a constant energy level (60 % of theoretical, N60). Practice D 6066 allows the hammer drop height to be adjusted to provide 60 % energy.

7.5 Bring the sampler to the surface and open. Record the percent recovery to the nearest 1 % or the length of sample recovered to the nearest 0.01 ft (5 mm). Classify the soil samples recovered as to, in accordance with Practice D 2488, then place one or more representative portions of the sample into sealable moisture-proof containers (jars) without ramming or distorting any apparent stratification. Seal each container to prevent evaporation of soil moisture. Affix labels to the containers bearing job designation, boring number, sample depth, and the blow count per 0.5-foot (0.15-m) increment. Protect the samples against extreme temperature changes. If there is a soil change within the sampler, make a jar for each stratum and note its location in the sampler barrel. Samples should be preserved and transported in accordance with Practice D 4220 using Group B.

8. Data Sheet(s)/Form(s)

8.1 Data obtained in each borehole shall be recorded in accordance with the Subsurface Logging Guide D 5434 as required by the exploration program. An example of a sample data sheet is included in Appendix X1.

8.2 Drilling information shall be recorded in the field and shall include the following:

8.2.1 Name and location of job,

8.2.2 Names of crew,

8.2.3 Type and make of drilling machine,

8.2.4 Weather conditions,

8.2.5 Date and time of start and finish of borehole,

8.2.6 Boring number and location (station and coordinates, if available and applicable),

8.2.7 Surface elevation, if available,

8.2.8 Method of advancing and cleaning the borehole,

8.2.9 Method of keeping borehole open,

8.2.10 Depth of water surface to the nearest 0.1 ft (0.030 m) and drilling depth to the nearest 0.1 ft (0.030 m) at the time of a noted loss of drilling fluid, and time and date when reading or notation was made,

8.2.11 Location of strata changes, to the nearest 0.5 ft (15 cm),

8.2.12 Size of casing, depth of cased portion of borehole to the nearest 0.1 ft (0.030 m),

8.2.13 Equipment and Method A or B of driving sampler,

8.2.14 Sampler length and inside diameter of barrel, and if a sample basket retainer is used,

8.2.15 Size, type, and section length of the sampling rods, and

8.2.16 Remarks.

8.3 Data obtained for each sample shall be recorded in the field and shall include the following:

8.3.1 Top of sample depth to the nearest 0.1 ft (0.030 m) and, if utilized, the sample number,

8.3.2 Description of soil,

8.3.3 Strata changes within sample,

8.3.4 Sampler penetration and recovery lengths to the nearest 0.1 ft (0.030 m), and

8.3.5 Number of blows per 0.5 foot (0.015 m) or partial increment.

9. Precision and Bias

9.1 *Precision*—Test data on precision is not presented due to the nature of this test method. It is either not feasible or too costly at this time to have ten or more agencies participate in an in situ testing program at a given site.

9.1.1 The Subcommittee 18.02 is seeking additional data from the users of this test method that might be used to make a limited statement on precision. Present knowledge indicates the following:

9.1.1.1 Variations in *N*-values of 100 % or more have been observed when using different standard penetration test apparatus and drillers for adjacent boreholes in the same soil formation. Current opinion, based on field experience, indicates that when using the same apparatus and driller, *N*-values in the same soil can be reproduced with a coefficient of variation of about 10 %.

9.1.1.2 The use of faulty equipment, such as an extremely massive or damaged anvil, a rusty cathead, a low speed cathead, an old, oily rope, or massive or poorly lubricated rope sheaves can significantly contribute to differences in *N*-values obtained between operator-drill rig systems.

9.2 *Bias*—There is no accepted reference value for this test method, therefore, bias cannot be determined.

10. Keywords

10.1 blow count; in-situ test; penetration resistance; soil; split-barrel sampling; standard penetration test

APPENDIX

(Nonmandatory Information)

X1. Example Data Sheet

X1.1 See Fig. 5.

DRILLERS BORING LOG

Project ______ Project No ______ Boring No ______

Location ______ Sheet ___ of ___

Date Started ______ Date Completed ______

Drill Crew:

Boring Location
Station ______ Offset ______

Elevation

Strata Depth		Soil Description and Remarks	Sample Type	No.	Depth		Recovery	N-Values		
From	To				From	To		6"	6"	6"

Drill Rig Type ______

Method Of Drilling:

Auger ______ Size ______

Wash ______ Water ______ Mud ______

Hammer Type

Auto ______ Manual ______

Split-Spoon Type

Length ______ Liner Used ______

Boring Size ______ Bit Used ______

Casing Size ______ Length ______

Weather ______

Non-Drilling Time (Hrs.)

Boring Layout ______ Moving ______

Hauling Water ______ Standby ______

Water Level @ ______ Date ______ Time ______

@ ______ Date ______ Time ______

@ ______ Date ______ Time ______

Cave-in Depth

@ ______ Date ______ Time ______

FIG. 5 Example Data Sheet

SUMMARY OF CHANGES

Committee D18 has identified the location of selected changes to this standard since the last issue (D 1586 – 99) that may impact the use of this standard. (Approved February 1, 2008.)

(*1*) There have been numerous changes to this standard to list them separately. From the most recent main ballot process, additional changes were requested and incorporated into this newest revision. Stated below is a highlight of some of the changes.
(*2*) Scope was completely revised.
(*3*) Referenced Documents updated to include new standards.
(*4*) Terminology: added section on Definitions.
(*5*) Significance and Use: clarified use of the SPT test.
(*6*) Apparatus: general editorial changes.
(*7*) Sampling and Testing Procedure: general editorial changes.
(*8*) Data Sheets/Forms: general editorial changes.
(*9*) Precision and Bias: added Sections 9.1.1.1 and 9.1.1.2.

Table 1
EXAMPLE SOIL DESCRIPTIONS

POORLY GRADED SAND (SP), light brown, moist, loose, fine sand size

FAT CLAY (CH), dark gray, moist, stiff

SILT (ML), light greenish gray, wet, very loose, some mica, lacustrine

WELL-GRADED SAND WITH GRAVEL (SM), reddish brown, moist, dense, subangular gravel to 0.6 inches max

POORLY GRADED SAND WITH SILT (SP-SM), white, wet, medium dense

ORGANIC SOIL WITH SAND (OH), dark brown to black, wet, firm to stiff but spongy undisturbed, becomes soft and sticky when remolded, many fine roots, trace of mica

SILTY GRAVEL WITH SAND (GM), brownish red, moist, very dense, subrounded gravel to 1.2 inches max

INTERLAYERED SILT (60 percent) AND CLAY (40 percent): SILT WITH SAND (ML), medium greenish gray, nonplastic, sudden reaction to shaking, layers mostly 1.5 to 8.3 inches thick; LEAN CLAY (CL), dark gray, firm and brittle undisturbed, becomes very soft and sticky when remolded, layers 0.2 to 1.2 inches thick

SILTY SAND WITH GRAVEL (SM), light yellowish brown, moist, medium dense, weak gravel to 1.0 inches max, very few small particles of coal, fill

SANDY ELASTIC SILT (MH), very light gray to white, wet, stiff, weak calcareous cementation

LEAN CLAY WITH SAND (CL/MH), dark brownish gray, moist, stiff

WELL-GRADED GRAVEL WITH SILT (GW-GM), brown, moist, very dense, rounded gravel to 1.0 inches max

SF032/010.50

Table 2
CRITERIA FOR DESCRIBING MOISTURE CONDITION

Description	Criteria
Dry	Absence of moisture, dusty, dry to the touch
Moist	Damp, but no visible water
Wet	Visible free water, usually soil is below water table

Table 3
RELATIVE DENSITY OF COARSE-GRAINED SOIL
(Developed from Sowers, 1979)

Blows/Ft	Relative Density	Field Test
0-4	Very loose	Easily penetrated with ½-in. steel rod pushed by hand
5-10	Loose	Easily penetrated with ½-in. steel rod pushed by hand
11-30	Medium	Easily penetrated with ½-in. steel rod driven with 5-lb hammer
31-50	Dense	Penetrated a foot with ½-in. steel rod driven with 5-lb hammer
>50	Very dense	Penetrated only a few inches with ½-in. steel rod driven with 5-lb hammer

Table 4
CONSISTENCY OF FINE-GRAINED SOIL
(Developed from Sowers, 1979)

Blows/Ft	Consistency	Pocket Penetrometer (TSF)	Torvane (TSF)	Field Test
<2	Very soft	<0.25	<0.12	Easily penetrated several inches by fist
2-4	Soft	0.25-0.50	0.12-0.25	Easily penetrated several inches by thumb
5-8	Firm	0.50-1.0	0.25-0.5	Can be penetrated several inches by thumb with moderate effort
9-15	Stiff	1.0-2.0	0.5-1.0	Readily indented by thumb, but penetrated only with great effort
16-30	Very stiff	2.0-4.0	1.0-2.0	Readily indented by thumbnail
>30	Hard	>4.0	>2.0	Indented with difficulty by thumbnail

STANDARD OPERATING PROCEDURE

Decontamination of Personnel and Equipment

I. Purpose

To provide general guidelines for the decontamination of personnel, sampling equipment, and monitoring equipment used in potentially contaminated environments.

II. Scope

This is a general description of decontamination procedures.

III. Equipment and Materials

- Demonstrated analyte-free, deionized ("DI") water (specifically, ASTM Type II water or lab-grade DI water)
- Potable water; must be from a municipal water supplier, otherwise an analysis must be run for appropriate volatile and semivolatile organic compounds and inorganic chemicals (e.g., Target Compound List and Target Analyte List chemicals)
- 2.5% (W/W) Liquinox® and water solution
- Concentrated (V/V) pesticide grade isopropanol (DO NOT USE ACETONE)
- Large plastic pails or tubs for Liquinox® and water, scrub brushes, squirt bottles for Liquinox® solution, methanol and water, plastic bags and sheets
- DOT approved 55-gallon drum for disposal of waste
- Personal Protective Equipment as specified by the Health and Safety Plan
- Decontamination pad and steam cleaner/high pressure cleaner for large equipment

IV. Procedures and Guidelines

A. PERSONNEL DECONTAMINATION

To be performed after completion of tasks whenever potential for contamination exists, and upon leaving the exclusion zone.

1. Wash boots in Liquinox® solution, then rinse with water. If disposable latex booties are worn over boots in the work area, rinse with Liquinox® solution, remove, and discard into DOT-approved 55-gallon drum.

2. Wash outer gloves in Liquinox® solution, rinse, remove, and discard into DOT-approved 55-gallon drum.

3. Remove disposable coveralls ("Tyveks") and discard into DOT-approved 55-gallon drum.

4. Remove respirator (if worn).

5. Remove inner gloves and discard.

6. At the end of the work day, shower entire body, including hair, either at the work site or at home.

7. Sanitize respirator if worn.

B. SAMPLING EQUIPMENT DECONTAMINATION—GROUNDWATER SAMPLING PUMPS

Sampling pumps are decontaminated after each use as follows.

1. Don phthalate-free gloves.

2. Spread plastic on the ground to keep equipment from touching the ground

3. Turn off pump after sampling. Remove pump from well and remove and dispose of tubing. Place pump in decontamination tube.

4. Turn pump back on and pump 1 gallon of Liquinox® solution through the sampling pump.

5. Rinse with 1 gallon of 10% isopropanol solution pumped through the pump. (DO NOT USE ACETONE). (Optional)

6. Rinse with 1 gallon of tap water. (deionized water may be substituted for tap water)

7. Rinse with 1 gallon of deionized water.

8. Keep decontaminated pump in decontamination tube or remove and wrap in aluminum foil or clean plastic sheeting.

9. Collect all rinsate and dispose of in a DOT-approved 55-gallon drum.

10. Decontamination materials (e.g., plastic sheeting, tubing, etc.) that have come in contact with used decontamination fluids or sampling equipment will be disposed of in either DOT-approved 55-gallon drums or with solid waste in garbage bags, dependent on Facility/project requirements.

C. SAMPLING EQUIPMENT DECONTAMINATION—OTHER EQUIPMENT

Reusable sampling equipment is decontaminated after each use as follows.

1. Don phthalate-free gloves.
2. Before entering the potentially contaminated zone, wrap soil contact points in aluminum foil (shiny side out).
3. Rinse and scrub with potable water.
4. Wash all equipment surfaces that contacted the potentially contaminated soil/water with Liquinox® solution.
5. Rinse with potable water.
6. Rinse with distilled or potable water and isopropanol solution (DO NOT USE ACETONE). (Optional)
7. Air dry.
8. Rinse with deionized water.
9. Completely air dry and wrap exposed areas with aluminum foil (shiny side out) for transport and handling if equipment will not be used immediately.
10. Collect all rinsate and dispose of in a DOT-approved 55-gallon drum.
11. Decontamination materials (e.g., plastic sheeting, tubing, etc.) that have come in contact with used decontamination fluids or sampling equipment will be disposed of in DOT-approved 55-gallon drums or with solid waste in garbage bags, dependent on Facility/project requirements.

D. HEALTH AND SAFETY MONITORING EQUIPMENT DECONTAMINATION

1. Before use, wrap soil contact points in plastic to reduce need for subsequent cleaning.
2. Wipe all surfaces that had possible contact with contaminated materials with a paper towel wet with Liquinox® solution, then a towel wet with methanol solution, and finally three times with a towel wet with distilled water. Dispose of all used paper towels in a DOT-approved 55-gallon drum or with solid waste in garbage bags, dependent on Facility/project requirements.

E. SAMPLE CONTAINER DECONTAMINATION

The outsides of sample bottles or containers filled in the field may need to be decontaminated before being packed for shipment or handled by personnel without hand protection. The procedure is:

1. Wipe container with a paper towel dampened with Liquinox® solution or immerse in the solution AFTER THE CONTAINERS HAVE BEEN SEALED. Repeat the above steps using potable water.
2. Dispose of all used paper towels in a DOT-approved 55-gallon drum or with solid waste in garbage bags, dependent on Facility/project requirements.

F. HEAVY EQUIPMENT AND TOOLS

Heavy equipment such as drilling rigs, drilling rods/tools, and the backhoe will be decontaminated upon arrival at the site and between locations as follows:

1. Set up a decontamination pad in area designated by the Facility
2. Steam clean heavy equipment until no visible signs of dirt are observed. This may require wire or stiff brushes to dislodge dirt from some areas.

V. Attachments

None.

VI. Key Checks and Items

- Clean with solutions of Liquinox®, Liquinox® solution (optional), and distilled water.
- Do not use acetone for decontamination.
- Drum all contaminated rinsate and materials.
- Decontaminate filled sample bottles before relinquishing them to anyone.

STANDARD OPERATING PROCEDURE

Preparing Field Log Books

I. Purpose

This SOP provides general guidelines for entering field data into log books during site investigation and remediation activities.

II. Scope

This is a general description of data requirements and format for field log books. Log books are needed to properly document all field activities in support of data evaluation and possible legal activities.

III. Equipment and Materials

- Log book
- Indelible pen

IV. Procedures and Guidelines

Properly completed field log books are a requirement for all of the work we perform under the Navy CLEAN contract. Log books are legal documents and, as such, must be prepared following specific procedures and must contain required information to ensure their integrity and legitimacy. This SOP describes the basic requirements for field log book entries.

A. PROCEDURES FOR COMPLETING FIELD LOG BOOKS

1. Field notes commonly are kept in bound, hard-cover logbooks used by surveyors and produced, for example, by Peninsular Publishing Company and Sesco, Inc. Pages should be water resistant and notes should be taken only with water-proof, non-erasable permanent ink, such as that provided in Rite in the Rain® or Sanford Sharpie® permanent markers. **Note:** for sites where PFC is being analyzed for, Rite-in-the-Rain®, Sanford Sharpie®, or anything water-resistant or with Teflon® cannot be used in the field. All field book materials must be "fluorine free". Acceptable substitutes would be a sewn notebook without a plastic cover, or loose-leaf notebook paper.
2. On the inside cover of the log book the following information should be included:

- Company name and address
- Log-holders name if log book was assigned specifically to that person
- Activity or location
- Project name
- Project manager's name
- Phone numbers of the company, supervisors, emergency response, etc.

3. All lines of all pages should be used to prevent later additions of text, which could later be questioned. Any line not used should be marked through with a line and initialed and dated. Any pages not used should be marked through with a line, the author's initials, the date, and the note "Intentionally Left Blank."
4. If errors are made in the log book, cross a single line through the error and enter the correct information. All corrections shall be initialed and dated by the personnel performing the correction. If possible, all corrections should be made by the individual who made the error.
5. Daily entries will be made chronologically.
6. Information will be recorded directly in the field log book during the work activity. Information will not be written on a separate sheet and then later transcribed into the log book.
7. Each page of the log book will have the date of the work and the note takers initials.
8. The final page of each day's notes will include the note-takers signature as well as the date.
9. Only information relevant to the subject project will be added to the log book.
10. The field notes will be copied and the copies sent to the Project Manager or designee in a timely manner (at least by the end of each week of work being performed).

B. INFORMATION TO BE INCLUDED IN FIELD LOG BOOKS

1. Entries into the log book should be as detailed and descriptive as possible so that a particular situation can be recalled without reliance on the collector's memory. Entries must be legible and complete.
2. General project information will be recorded at the beginning of each field project. This will include the project title, the project number, and project staff.

3. Scope: Describe the general scope of work to be performed each day.

4. Weather: Record the weather conditions and any significant changes in the weather during the day.

5. Tail Gate Safety Meetings: Record time and location of meeting, who was present, topics discussed, issues/problems/concerns identified, and corrective actions or adjustments made to address concerns/ problems, and other pertinent information.

6. Standard Health and Safety Procedures: Record level of personal protection being used (e.g., level D PPE), record air monitoring data on a regular basis and note where data were recording (e.g., reading in borehole, reading in breathing zone, etc). Also record other required health and safety procedures as specified in the project specific health and safety plan.

7. Instrument Calibration; Record calibration information for each piece of health and safety and field equipment.

8. Personnel: Record names of all personnel present during field activities and list their roles and their affiliation. Record when personnel and visitors enter and leave a project site and their level of personal protection.

9. Communications: Record communications with project manager, subcontractors, regulators, facility personnel, and others that impact performance of the project.

10. Time: Keep a running time log explaining field activities as they occur chronologically throughout the day.

11. Deviations from the Work Plan: Record any deviations from the work plan and document why these were required and any communications authorizing these deviations.

12. Heath and Safety Incidents: Record any health and safety incidents and immediately report any incidents to the Project Manager.

13. Subcontractor Information: Record name of company, record names and roles of subcontractor personnel, list type of equipment being used and general scope of work. List times of starting and stopping work and quantities of consumable equipment used if it is to be billed to the project.

14. Problems and Corrective Actions: Clearly describe any problems encountered during the field work and the corrective actions taken to address these problems.

15. Technical and Project Information: Describe the details of the work being performed. The technical information recorded will vary significantly between projects. The project work plan will describe the specific activities to be performed and may also list requirements

for note taking. Discuss note-taking expectations with the Project Manager prior to beginning the field work.

16. Any conditions that might adversely affect the work or any data obtained (e.g., nearby construction that might have introduced excessive amounts of dust into the air).

17. Sampling Information; Specific information that will be relevant to most sampling jobs includes the following:

    - Description of the general sampling area – site name, buildings and streets in the area, etc.
    - Station/Location identifier
    - Description of the sample location – estimate location in comparison to two fixed points – draw a diagram in the field log book indicating sample location relative to these fixed points – include distances in feet.
    - Sample matrix and type
    - Sample date and time
    - Sample identifier
    - Draw a box around the sample ID so that it stands out in the field notes
    - Information on how the sample was collected – distinguish between "grab," "composite," and "discrete" samples
    - Number and type of sample containers collected
    - Record of any field measurements taken (i.e. pH, turbidity, dissolved oxygen, and temperature, and conductivity)
    - Parameters to be analyzed for, if appropriate
    - Descriptions of soil samples and drilling cuttings can be entered in depth sequence, along with PID readings and other observations. Include any unusual appearances of the samples.

C. SUGGESTED FORMAT FOR RECORDING FIELD DATA

1. Use the left side border to record times and the remainder of the page to record information (see attached example).

2. Use tables to record sampling information and field data from multiple samples.

3. Sketch sampling locations and other pertinent information.

4. Sketch well construction diagrams.

V. Attachments

Example field notes.

Chain-of-Custody

I Purpose

The purpose of this SOP is to provide information on chain-of-custody procedures to be used under the CLEAN Program.

II Scope

This procedure describes the steps necessary for transferring samples through the use of Chain-of-Custody Records. A Chain-of-Custody Record is required, without exception, for the tracking and recording of samples collected for on-site or off-site analysis (chemical or geotechnical) during program activities (except wellhead samples taken for measurement of field parameters). Use of the Chain-of-Custody Record Form creates an accurate written record that can be used to trace the possession and handling of the sample from the moment of its collection through analysis. This procedure identifies the necessary custody records and describes their completion. This procedure does not take precedence over region specific or site-specific requirements for chain-of-custody.

III Definitions

Chain-of-Custody Record Form - A Chain-of-Custody Record Form is a printed two-part form that accompanies a sample or group of samples as custody of the sample(s) is transferred from one custodian to another custodian. One copy of the form must be retained in the project file.

Custodian - The person responsible for the custody of samples at a particular time, until custody is transferred to another person (and so documented), who then becomes custodian. A sample is under one's custody if:

- It is in one's actual possession.
- It is in one's view, after being in one's physical possession.
- It was in one's physical possession and then he/she locked it up to prevent tampering.
- It is in a designated and identified secure area.

Sample - A sample is physical evidence collected from a facility or the environment, which is representative of conditions at the point and time that it was collected.

IV. Procedures

The term "chain-of-custody" refers to procedures which ensure that evidence presented in a court of law is valid. The chain-of-custody procedures track the evidence from the time and place it is first obtained to the courtroom, as well as providing security for the evidence as it is moved and/or passed from the custody of one individual to another.

Chain-of-custody procedures, recordkeeping, and documentation are an important part of the management control of samples. Regulatory agencies must be able to provide the chain-of-possession and custody of any samples that are offered for evidence, or that form the basis of analytical test results introduced as evidence. Written procedures must be available and followed whenever evidence samples are collected, transferred, stored, analyzed, or destroyed.

Sample Identification

The method of identification of a sample depends on the type of measurement or analysis performed. When *in situ* measurements are made, the data are recorded directly in bound logbooks or other field data records with identifying information.

Information which shall be recorded in the field logbook, when in-situ measurements or samples for laboratory analysis are collected, includes:

- Field Sampler(s),
- Contract Task Order (CTO) Number,
- Project Sample Number,
- Sample location or sampling station number,
- Date and time of sample collection and/or measurement,
- Field observations,
- Equipment used to collect samples and measurements, and
- Calibration data for equipment used

Measurements and observations shall be recorded using waterproof ink.

Sample Label

Samples, other than for *in situ* measurements, are removed and transported from the sample location to a laboratory or other location for analysis. Before removal, however, a sample is often divided into portions, depending upon the analyses to be performed. Each portion is preserved in accordance with the Sampling and Analysis Plan. Each sample container is identified by a sample label (see Attachment A). Sample labels are provided, along with sample containers, by the analytical laboratory. The information recorded on the sample label includes:

- Project – Name of project site.
- Sample Identification - The unique sample number identifying this sample.
- Date - A six-digit number indicating the day, month, and year of sample collection (e.g., 05/21/17).

- Time - A four-digit number indicating the 24-hour time of collection (for example: 0954 is 9:54 a.m., and 1629 is 4:29 p.m.).
- Medium - Water, soil, sediment, sludge, waste, etc.
- Sample Type - Grab or composite.
- Preservation - Type and quantity of preservation added.
- Analysis - VOA, BNAs, PCBs, pesticides, metals, cyanide, other.
- Sampled By - Printed name or initials of the sampler.
- Remarks - Any pertinent additional information.

The field team should always follow the sample ID system prepared by the Project Chemist and reviewed by the Project Manager.

Chain-of-Custody Procedures

After collection, separation, identification, and preservation, the sample is maintained under chain-of-custody procedures until it is in the custody of the analytical laboratory and has been stored or disposed.

Field Custody Procedures

- Samples are collected as described in the site Sampling and Analysis Plan. Care must be taken to record precisely the sample location and to ensure that the sample number on the label matches the Chain-of-Custody Record exactly.

- A Chain-of-Custody Record will be prepared for each individual cooler shipped and will include ***only*** the samples contained within that particular cooler. The Chain-of-Custody Record for that cooler will then be sealed in a zip-log bag and placed in the cooler prior to sealing. This ensures that the laboratory properly attributes trip blanks with the correct cooler and allows for easier tracking should a cooler become lost during transit.

- The person undertaking the actual sampling in the field is responsible for the care and custody of the samples collected until they are properly transferred or dispatched.

- When photographs are taken of the sampling as part of the documentation procedure, the name of the photographer, date, time, site location, and site description are entered sequentially in the site logbook as photos are taken. Once downloaded to the server or developed, the electronic files or photographic prints shall be serially numbered, corresponding to the logbook descriptions; photographic prints will be stored in the project files. To identify sample locations in photographs, an easily read sign with the appropriate sample location number should be included.

- Sample labels shall be completed for each sample, using waterproof ink unless prohibited by weather conditions (e.g., a logbook notation would explain that a pencil was used to fill out the sample label if the pen would not function in freezing weather.)

Transfer of Custody and Shipment

Samples are accompanied by a Chain-of-Custody Record Form. **A Chain-of-Custody Record Form must be completed for each cooler and should include only the samples contained within that cooler**. A Chain-of-Custody Record Form example is shown in Attachment B. When transferring the possession of samples, the individuals relinquishing and receiving will sign, date, and note the time on the Record. This Record documents sample custody transfer from the sampler, often through another person, to the analyst in the laboratory. The Chain-of-Custody Record is filled out as given below:

- Enter header information (CTO number, samplers, and project name).
- Enter sample specific information (sample number, media, sample analysis required and analytical method grab or composite, number and type of sample containers, and date/time sample was collected).
- Sign, date, and enter the time under "Relinquished by" entry.
- Have the person receiving the sample sign the "Received by" entry. If shipping samples by a common carrier, print the carrier to be used and enter the airbill number under "Remarks," in the bottom right corner;
- Place the original (top, signed copy) of the Chain-of-Custody Record Form in a plastic zipper-type bag or other appropriate sample-shipping package. Retain the copy with field records.
- Sign and date the custody seal, a 1-inch by 3-inch white paper label with black lettering and an adhesive backing. Attachment C is an example of a custody seal. The custody seal is part of the chain-of-custody process and is used to prevent tampering with samples after they have been collected in the field. Custody seals shall be provided by the analytical laboratory.
- Place the seal across the shipping container opening (front and back) so that it would be broken if the container were to be opened.
- Complete other carrier-required shipping papers.

The custody record is completed using waterproof ink. Any corrections are made by drawing a line through and initialing and dating the change, then entering the correct information. Erasures are not permitted.

Common carriers will usually not accept responsibility for handling Chain-of-Custody Record Forms; this necessitates packing the record in the shipping container (enclosed with other documentation in a plastic zipper-type bag). As long as custody forms are sealed inside the shipping container and the custody seals are intact, commercial carriers are not required to sign the custody form.

The laboratory representative who accepts the incoming sample shipment signs and dates the Chain-of-Custody Record, completing the sample transfer process. It is then the laboratory's responsibility to maintain internal logbooks and custody records throughout sample preparation and analysis.

V Quality Assurance Records

Once samples have been packaged and shipped, the Chain-of-Custody copy and airbill receipt become part of the quality assurance record.

VI Attachments

A. Sample Label
B. Chain of Custody Form
C. Custody Seal

VII References

USEPA. *User's Guide to the Contract Laboratory Program*. Office of Emergency and Remedial Response, Washington, D.C. (EPA/540/P-91/002), January 1991.

Attachment A

Example Sample Label

QAL

Quality Analytical Laboratories, Inc.
2567 Fairlane Drive
Montgomery, Alabama 36116
PH. (334)271-2440

Client ____________________
Sample No. ____________________
Location ____________________

Analysis ____________________

Preservative HCL
Date ____________ By ____________

CEIMIC
CORPORATION
10 Dean Knauss Drive, Narragansett, R.I. 02882 • (401) 782-8900

SITE NAME	DATE
ANALYSIS	TIME
	PRESERVATIVE

SAMPLE TYPE

☐ Grab ☐ Composite ☐ Other ________

COLLECTED BY:

Attachment B
Example Chain-of-Custody Record

CH2M HILL
APPLIED SCIENCES LABORATORY

CHAIN OF CUSTODY RECORD AND AGREEMENT TO PERFORM SERVICES

CH2M Hill Project #

Purchase Order #

Project Name

Company Name CH2M HILL Office

Project Manager & Phone #
Mr. [ ]
Ms. [ ]
Dr. [ ]

Report Copy to:

Requested Completion Date:

Sampling Requirements: SDWA ☐ NPDES ☐ RCRA ☐ OTHER ____

Sample Disposal: Dispose ☐ Return ☐

OF CONTAINERS

LAB TEST CODES

ANALYSES REQUESTED

SHADED AREA– FOR LAB USE ONLY

Lab 1 #	Lab 2 #
Quote #	Kit Request #
Project #	
No. of Samples	Page of
Login	LIMS Ver

Sampling Date	Sampling Time	Type COMP	Type GRAB	Matrix WATER	Matrix SOIL	Matrix AIR	CLIENT SAMPLE ID (9 CHARACTERS)	# OF CONTAINERS	ANALYSES REQUESTED	REMARKS	LAB 1 ID	LAB 2 ID

Sampled By & Title (Please sign and print name)	Date/Time	Relinquished By (Please sign and print name)	Date/Time	QC Level: 1 2 3 Other: ____
Received By (Please sign and print name)	Date/Time	Relinquished By (Please sign and print name)	Date/Time	COC Rec / ICE
Received By (Please sign and print name)	Date/Time	Relinquished By (Please sign and print name)	Date/Time	Ana Req / TEMP; Cust Seal / Ph
Received By (Please sign and print name)	Date/Time	Shipped Via UPS BUS Fed-Ex Hand Other ____	Shipping #	
Work Authorized By (Please sign and print name)	Remarks			

Instructions and Agreement Provisions on Reverse Side

DISTRIBUTION: Original - LAB, Yellow - LAB, Pink - Client

REV 3/94 FORM 340

Attachment C

Example Custody Seal

CH2M HILL

CUSTODY SEAL

Date ______________________ ______________________

Signature ______________________ ______________________

STANDARD OPERATING PROCEDURE

Packaging and Shipping Procedures for Low-Concentration Samples

I. Purpose and Scope

The purpose of this guideline is to describe the packaging and shipping of low-concentration samples of various media to a laboratory for analysis.

II. Scope

The guideline only discusses the packaging and shipping of samples that are anticipated to have low concentrations of chemical constituents. Whether or not samples should be classified as low-concentration or otherwise will depend upon the site history, observation of the samples in the field, odor, and photoionization-detector readings.

If the site is known to have produced high-concentration samples in the past or the sampler suspects that high concentrations of contaminants might be present in the samples, then the sampler should conservatively assume that the samples cannot be classified as low-concentration. Samples that are anticipated to have medium to high concentrations of constituents should be packaged and shipped accordingly.

If warranted, procedures for dangerous-goods shipping may be implemented. Dangerous goods and hazardous materials pose an unreasonable risk to health, safety, or property during transportation without special handling. As a result only employees who are trained under Jacobs Dangerous Goods Shipping course may ship or transport dangerous goods. Employees should utilize the HAZMAT ShipRight tool on the Virtual Office and/or contact a designated Jacobs HazMat advisor with questions.

III. Equipment and Materials

- Coolers
- Clear tape
- Strapping tape
- Contractor bags
- Absorbent pads or equivalent
- Resealable bags
- Bubble bags (for glass bottle ware)
- Bubble wrap (if needed)
- Ice
- Chain-of-Custody form (completed)
- Custody seals

IV. Procedures and Guidelines

Low-Concentration Samples

A. Prepare coolers for shipment:

- Tape drains shut.
- Place mailing label with laboratory address on top of coolers.
- Fill bottom of coolers with absorbent pads or similar material.
- Place a contractor bag inside the cooler.

B. Affix appropriate adhesive sample labels to each container. Protect with clear packing tape.

C. Arrange decontaminated sample containers in groups by sample number. Consolidate VOC samples into one cooler to minimize the need for trip blanks. Cross check CoC to ensure all samples are present.

D. Seal each glass sample bottle within a separate bubble bag (VOCs grouped per sample location). Sample labels should be visible through the bag. Whenever possible, group samples per location for all analytes and place in resealable bags. Make sure to release as much air as practicable from the bag before sealing.

E. Arrange sample bottles in coolers so that they do not touch.

F. If ice is required to preserve the samples, cubes should be repackaged in resealable bags and placed on and around the containers.

G. Fill remaining spaces with bubble wrap if needed.

H. Complete and sign chain-of-custody form (or obtain signature) and indicate the time and date it was relinquished to Federal Express or the courier.

J Close lid and latch.

K. Carefully peel custody seals from backings and place intact over lid openings (right front and left back). Cover seals with clear packing tape.

L. Tape cooler shut on both ends, making several complete revolutions with strapping tape. Cover custody seals with clear packing tape to avoid seals being able to be peeled from the cooler.

M. Relinquish to Federal Express or to a courier arranged with the laboratory. Scan airbill receipt and CoC and send to the sample documentation coordinator along with the other documentation.

Medium- and High-Concentration Samples:

Medium- and high-concentration samples are packaged using the same techniques used to package low-concentration samples, with potential additional restrictions. If applicable, the sample handler must refer to instructions associated with the shipping of dangerous goods for the necessary procedures for shipping by Federal Express or other overnight carrier. If warranted, procedures for dangerous-goods shipping may be implemented. Dangerous goods and hazardous materials pose an unreasonable risk to health, safety, or property during transportation without special handling. As a result, only employees who are trained under Jacobs Dangerous Goods Shipping course may ship or transport dangerous goods. Employees should utilize the HAZMAT ShipRight tool on the Virtual Office and/or contact a designated Jacobs HazMat advisor with questions.

V. Attachments

None.

VI. Key Checks and Items

- Be sure laboratory address is correct on the mailing label
- Pack sample bottles carefully, with adequate packaging and without allowing bottles to touch
- Be sure there is adequate ice
- Include chain-of-custody form
- Include custody seals

APPROVED:

_____________________________ 5/31/13
Technical Services Manager Date

_____________________________ 5/31/13
Corporate Certified Health Physicist Date

1.0 PURPOSE

This administrative procedure describes the major elements of the Radiation Protection Program for Perma-Fix Environmental Services, Inc. (PESI). As applicable, this administrative procedure references sections in the Radiation Protection Plan and project procedures which describe the program in more detail.

2.0 APPLICABILITY

These program descriptions apply to personnel who plan, review, supervise, or perform work involving radiation protection activities during remediation.

3.0 REFERENCES

References are listed in the specific Project Procedures that comprise this Radiation Protection Program.

4.0 DEFINITIONS

Radiation Work Permit (RWP): A document or series of documents prepared by Radiation Protection to inform workers of the radiological and industrial hygiene conditions that exist in the work area and the radiological requirements for the job.

Radioactive Material: Material activated or contaminated by the operation or remediation of the site and byproduct material procured and used to support the operation or remediation.

Radiological Area: Any area within a Restricted Area which require posting as a Radiation Area, Contamination Area, Airborne Radioactivity Area, High Contamination Area, or High Radiation Area.

Restricted Area: An area to which access is limited to protect individuals against undue risks from exposure to radiation, radioactive materials, and chemical contaminants. All posted radiological or chemical areas are Restricted Areas.

5.0 RESPONSIBILITIES

5.1 Radiation Safety Officer (RSO)

The RSO advises project management on all aspects of Radiation Protection and Operational Health Physics. The RSO directs all radiological safety activities on the project. The RSO has the authority to suspend operations and / or restrict personnel access at the project as a result of nonconformance to this SSHP, or other applicable regulations, and when radiological conditions change beyond the scope of an HWP. The RSO is responsible for:

- Implementing and ensuring compliance with RPP's policies and procedures.
- Inspect work activities to ensure operations, including off-normal activities, are being conducted according to the facility or project requirements, applicable federal regulations, and industry accepted As-Low-As-Reasonably-Achievable (ALARA) principles.
- Reviewing and approving work plans, Radiation Work Permits, and RPP procedures.
- Trending radiation work performance of project personnel including contamination and radiation exposure control.
- Identifying, reviewing, and documenting nonconformance, their causes and corrective actions for incidents associated with radiation protection.
- Ensuring an effective ALARA Program including conducting onsite radiation safety and health briefings.
- Ensuring documentation of any RPP safety violation.
- Reviewing survey data.
- Conducting briefings concerning radiological work activities.
- Ensuring that radiological records are complete, clear and legible, meet the intended purpose, and are regularly transmitted to document control for archive.
- Ensuring Restricted Areas are correctly identified, posted and marked.
- Performing or coordinating regular internal audits of the RPP.

5.2 Radiation Protection Technicians (RPTs)

RPTs report directly to the RSO. RPTs are assigned by the RSO to provide support to each major field activity for implementation of RPP requirements. RPTs provide guidance in RPP matters to field personnel. RPTs have stop-work authority for radiological safety matters and activities that could result in an unsafe condition being present. RPTs are responsible for the following:

- Conducting routine and job-specific radiological surveys (i.e., radiation, contamination, and airborne radioactivity).
- Establishing radiological postings.
- Implementing the personal protective equipment (PPE) and respiratory protection programs for the purpose of keeping radiation exposures ALARA.

- Maintaining and operating portable Health Physics survey instrumentation used in the performance of Radiation Protection (RP) activities.
- Performing unconditional release surveys of material from the restricted area.
- Performing transportation radiological surveys according to applicable U.S. Department of Transportation (DOT) regulations.
- Assisting the SSHO with IH&S monitoring and inspections to a level commensurate with training and experience.

5.3 Project Supervisors

All Project Supervisors are responsible for:

- Ensuring personnel under their direction comply with RPP requirements.
- Providing information on projected work activities to the RPP organization.
- Notifying RP personnel of any radiological problems encountered.
- Ensuring workers are prepared for tasks with tools, equipment and training to minimize time spent in radiological areas.

5.4 Project Radiation Workers

All Project Radiation Workers and individuals entering radiologically controlled areas are responsible for:

- Obeying promptly “stop-work” and “evacuate” orders from RP personnel and the SSHO.
- Obeying posted, oral and written radiological control instructions and procedures, including instructions on Radiation Work Permits and those in the SSHP.
- Immediately reporting lost dosimetry devices to RP personnel.
- Reporting medical radiation treatments to the RSO and supervisor.
- Keeping tack of personal radiation exposure status to ensure that administrative dose limits are not exceeded.
- Notifying RP personnel of faulty or alarming radiation protection equipment, and unsafe radiological conditions.

6.0 PREREQUISITES

None

7.0 PRECAUTIONS AND LIMITATIONS

None

8.0 APPARATUS

None

9.0 RECORDS

None

10.0 PROCEDURE

10.1 Radiation Protection Organization

1. The RPP Organization will provide appropriate personnel and resources to verify and maintain a radiologically safe working environment.
2. RPP staffing levels will be periodically reviewed to ensure that adequate staffing levels are maintained consistent with current and planned remediation activities.
3. The Project RPP Organization will have access to engineering and other personnel needed to support the Radiation Protection Program.
4. The development and control of RPP Project Procedures will be in accordance with the following guidelines:
    - Clearly defined scope, tasks, applicability, limiting conditions, precautions, consideration of special controls, reference to acceptance criteria and quality requirements.
    - Clearly understood text, using standard grammar, nomenclature and punctuation, concise instruction steps in a logical sequence, and references.
    - Review, approval, issuance, and control of changes and permanent revisions.

10.2 ALARA Program

All activities involving radiation and radioactive materials shall be conducted in such a manner that radiation exposure to workers and the general public are maintained As-Low-As-Reasonably-Achievable (ALARA), taking into account current technology and the economics of radiation exposure reduction in relationship to the benefits of health and safety. ALARA concepts are implemented throughout the entire RPP. ALARA-program requirements include:

1. Administrative controls and procedures endeavor to reduce individual and collective radiation exposures ALARA. Minimizing radiation exposure is accomplished by preliminary planning and scheduling, using proven and innovative engineering techniques and performing engineering reviews of proposed work plan changes.
2. Worker involvement and acceptance in minimizing radiation exposure is a key component of the ALARA Program. Workers are responsible to incorporate ALARA principles into work performance.
3. Work shall be planned in accordance with ALARA principles, involving input from discipline engineers, the project RPP staff and implementing supervisors.
4. An Embryo-Fetus Protection Program has been established for the Project and is specified in RPP-113, “Embryo-Fetus Protection”

10.3 Radiation Protection Audit Program

1. Internal / External Audits of the Radiation Protection Program should be performed, documented, and be of sufficient scope, depth, and frequency to

identify and resolve actual or potential performance deficiencies before significant quality problems are encountered. Audit frequency and criteria is determined by the RSO and / or SSHO.

2. The RSO and / or SSHO shall perform an annual review of RPP content and implementation as specified in 10 CFR 20.1101(c).

10.4 External and Internal Dosimetry Program

Internal and external dosimetry and exposure control requirements are defined in the PESI Radiation Protection Plan and includes:

- A discussion of applicable regulatory limits for occupational workers and members of the public.
- ALARA goals.
- Monitoring requirements.
- Recordkeeping requirements.
- Reporting requirements for both normal operations and incidents.

10.5 Radiation Protection Instrumentation Program

All instrumentation used to measure radiation and radioactive material will be maintained in accordance with their respective technical manuals and operating procedures This includes establishing criteria and requirements for the operation, calibration, response testing, maintenance, inventory and control of radiation protection instrumentation and equipment to comply with applicable regulations and conform with applicable ANSI standards. The Instrumentation Program is detailed by specific procedures including RP-108, RP-109, and RP-110.

10.6 Access Control Program

Access controls to radiological areas will be maintained at all times at the PESI. The administrative and physical measures used to control access to Restricted and/or Radiological Areas are established procedures RP-101, RP-102, and RP-103

10.7 Radiation Protection Surveillance Program

The Radiation Protection Surveillance Program provides for the conduct of radiological surveys in all areas controlled for the purpose of radiation and/or radioactivity. The Program encompasses both routine and non-routine surveys to be performed within the PESI. The specific requirements for conducting and documenting radiological surveys at the PESI are detailed in procedures RP-104, RP-105, RP-106, and RP-107

10.8 Radioactive Material Control Program

This Program provides guidance and requirements for control of radioactive materials. The Radioactive Material Control Program includes receipt, inventory, handling, and release of materials. It also provides for radioactive sealed source control, control of materials entering Restricted Areas and control of contaminated tools and equipment. The requirements of this program are established in RP-111

10.9 Respiratory Protection Program

It is not expected that respirators will be widely used by PESI staff for radiation protection purposes at PESI. As such the Respiratory Protection Program will be administered by the SSHO in accordance with the PESI Site Safety and Health Plan. The SSHO will consult with the RSO when respiratory protection is required for radiological purposes.

10.10 Radiological Training

The Radiological Training is required for PESI employees and/or subcontractors who perform work near, or in areas controlled for the purpose of radiation and/or radioactive materials as defined in Section 8.1 of the PESI Radiation Protection Plan. There are two basic levels of training: General Employee Radiation Training for visitors and non-radiation workers, Radiation Worker Training for workers who access Restricted Areas.

10.11 Radiation Protection Records

Radiation Protection Records are routinely developed to document all aspects of the Radiation Protection Program. Records are generated using clear concise text using standard grammar and punctuation. Records are reviewed for adequacy and completeness and transmitted to the Document Control organization for long-term retention.

PERMA-FIX ENVIRONMENTAL SERVICES		
TITLE: **Access Control**	**NO.:**	RP-101
	PAGE:	1 of 6
	DATE:	May 2014

APPROVED:

5/31/14
Technical Services Manager — Date

5/31/14
Corporate Certified Health Physicist — Date

1.0 PURPOSE

The purpose of this procedure is to provide consistent methodology for controlling the access of personnel, equipment, and vehicles into radiological areas.

2.0 APPLICABILITY

This procedure applies to all Project personnel and visitors, equipment, and vehicles entering Restricted Areas.

3.0 REFERENCES

1. 10 CFR 19, "Notices, Instructions and Reports to Workers Inspection."
2. 10 CFR 20, "Standards for Protection Against Radiation."
3. Perma-Fix Environmental Services (PESI) Radiation Protection Plan (RPP)
4. RPP-102, "Radiological Posting Requirements."
5. RPP-103, "Radiation Work Permits Preparation and Use."
6. 29 CFR 1910.120, "Hazardous Waste Operations and Emergency Response."

4.0 GENERAL

4.1 Discussion

Access controls are used to ensure the radiological safety of personnel entering into Restricted Areas. These controls include, but are not limited to Training, Dosimetry, Posting, Area Monitoring, and Radiation Work Permits (RWP).

4.2 Definitions

ALARA: Means as low as reasonably achievable.

GET: General Employee Training

GERT: General Employee Radiation Training

HAZWOPER: 40-Hour Hazardous Waste Operations and Emergency Response training in accordance with 29 CFR 1910.120

Radiation Worker: An individual who accesses any Restricted Area unescorted. Radiation Workers shall have successfully completed all requisite medical and training requirements for performing work in Restricted Areas. **RPT:** Radiation Protection Technician

Radiation Work Permit (RWP): A document or series of documents prepared by the Radiation Protection Group to inform workers of the radiological, industrial hygiene and other safety conditions which exist in the work area and task-related radiological and other safety requirements.

RSO: Radiation Safety Officer

SSHO: Site Safety and Health Officer

SRD: Self-Reading Dosimeter

Visitor: An individual who accesses the project site for purposes other than for assignment as a Project Worker (e.g., site visit, performance of an essential short-term task).

5.0 RESPONSIBILITIES

5.1 Site Safety & Health Officer (SSHO)

- The SSHO is responsible for ensuring that all activities performed within this procedure conform to the requirements of the PESI Site Safety & Health Plan (SSHP).
- Authorizing escorted visitor entries into Restricted Areas. This responsibility may be designated.
- Evaluating visitor entries to Restricted Areas to minimize or eliminate exposure risk to personnel who lack adequate training.

5.2 Radiation Safety Officer (RSO)

- Implementing this procedure.
- Approving RWPs to control access to Restricted Areas.
- Reviewing and approving training programs related to work in Restricted Areas.
- Implementing the requirements of the PESI Radiological Protection Program.
- Providing direction to the Project Personnel regarding radiological matters.

- Authorizing escorted visitor entries into Restricted Areas. This responsibility may be designated.
- Evaluating visitor entries to Restricted Areas to minimize or eliminate exposure risk to personnel who lack adequate training.

5.3 Radiation Protection Technician (RPT)

- Identifying and posting Restricted Areas.
- Providing RWP briefings to individuals entering Restricted Areas.
- Conducting radiation and contamination surveys, and keeping legible records.
- Monitoring work activities to ensure compliance with the requirements of the Radiological Protection Program.

5.4 Project Supervisor

- Ensuring that personnel assigned to work in Restricted Areas or with radioactive material, attend required training and perform work in a radiologically sound and safe manner.
- Contacting the RSO or designee, to obtain approval to bring escorted visitors into Restricted Areas.
- Notifying the RSO or designee, in advance (when possible) of the need to bring any non-project owned equipment / vehicles into the Restricted Area to arrange for baseline contamination surveys.

5.5 Project Personnel

- Attending designated training classes.
- Following directions from the RPT with regards to Safety and Health.
- Maintaining their personnel exposures ALARA.
- Limiting the amount of material taken into Restricted Areas to that necessary for task performance.
- Working in a manner so as to prevent spread of contamination and reduce airborne radiological emissions to the extent possible.

6.0 PREREQUISITES

6.1 Individuals requiring unescorted access into a Restricted Area shall submit the following documentation to the RSO **prior** to entry:

- Evidence of initial 40-Hour and 8-Hour Refresher OSHA HAZWOPER Training (if applicable)
- Current medical examination performed within the past 12 months.
- Evidence of successful completion of Site Orientation Training (GET/GERT) and Radiation Worker Training (RWT).

6.2 Individuals requiring unescorted access into a Restricted Area shall meet the requirements for Restricted Area access and have the following at a minimum:

- Thermoluminescence Dosimeter (TLD) or Self-Reading Dosimeter (SRD).
- Personal Protective Equipment (PPE) specified by posting and/or RWP.

6.3 Visitor access into Restricted Areas is limited to essential tasks which meet all of the following requirements:

- The task cannot be performed by appropriately trained Project Personnel
- The task is time critical in nature and would have a negative impact on safety & health or project operations if not performed.
- The task cannot be deferred until the Restricted Area is remediated or down posted.

7.0 PRECAUTIONS AND LIMITATIONS

- No unessential visitors shall be allowed access to the restricted areas.
- Visitors shall receive visitor specific site orientation training prior to accessing a restricted area. Training shall be documented.
- Personnel, equipment, and vehicle entry control shall be maintained for each radiological area.
- No radiological control(s) shall be installed in any area that would prevent the rapid evacuation of personnel in an emergency situation.
- Trained emergency response personnel (Fire Dept., Ambulance/EMT, Law Enforcement) responding to on-site emergencies are exempt from the requirements of this procedure.
- Any member of the public exposed to radiation and / or radioactive material shall not exceed 0.1 rem Total Effective Dose Equivalent per year.
- All visitors entering into a Restricted Area shall be escorted at all times by a qualified radiation worker. The RSO and SSHO or designee(s) shall approve these entries. The escort is responsible for visitor compliance with site protocols.
- Visitors may not enter a posted High Contamination Area, Radiation Area, High Radiation Area, or Airborne Radioactivity Area.
- Visitors shall not perform any work of an intrusive nature (i.e., digging, drilling, sampling, etc.) or an abrasive nature (i.e., welding, sanding, grinding, etc.) in Controlled Areas unless evaluated and approved by the RSO or designee.
- Visitors may only enter those areas where hazardous atmospheres do not exceed 50% of the Permissible Exposure Limit and where radiation exposures would not exceed the annual dose limit to a member of the public as specified in 10 CFR 20.
- The RSO shall ensure that risk of exposure to hazardous materials is minimized or eliminated prior to authorizing visitor entry into Restricted Areas. No work of an intrusive nature that may produce radioactive airborne particulates shall take place during visitor access to a restricted area.
- Visitors shall not be allowed to come into contact with tools, vehicles or materials that are contaminated above the release levels established in the SSHP.
- Project personnel who are required to escort individuals into a Restricted Area shall have successfully completed Radiation Worker Training (RWT), which includes training on the requirements of this procedure, and have a demonstrated knowledge of the site layout, site history, and emergency response protocols.

- Project personnel who are required to escort individuals into a Restricted Area shall ensure the visitors complete the "PESI Visitor Access Control Form" (see Attachment 1).
- RPTs shall perform exit frisking of visitors from Restricted Areas when frisking is required by RWP. Visitor access times and dates, PPE, controls and conditions shall be documented.

8.0 APPARATUS

None

9.0 RECORDS

- PESI Visitor Access Control Form
- RWP Access Registers are maintained under separate procedure.
- Quality Records generated under this procedure submitted to Document Control.

10.0 PROCEDURE

10.1 Restricted Areas

1. Enter the Restricted Area **ONLY** through the designated Access Control Point unless instructed otherwise by the RPT.
2. Inform the Access Control Point RPT of the nature of your work in the Restricted Area. Provide details as requested by the RPT.
3. Adhere to the requirements of Section 10.2 of this procedure if taking equipment or vehicles into the Restricted Area.
4. Review the applicable RWP and assemble and dress in the appropriate PPE.
5. Sign-in on the RWP Access Register. Signatures must be clear and legible, and must be accompanied by time of access.
6. Conduct all activities in a safe manner while working in the Restricted Area. Adhere to established safety and housekeeping protocols.
7. Exit the Restricted Area **ONLY** through the Access Control Point unless instructed otherwise by the RPT. Perform an exit frisk as required by RWP.
8. Sign-out on the appropriate RWP Access Register. Signatures must be clear and legible, and must be accompanied by time of egress.

10.2 Equipment and Vehicles Entering and Exiting Restricted Areas

1. Notify the RPT of any equipment / vehicles that need to be taken into a Restricted Area. Incoming surveys are performed on equipment and materials entering Restricted Areas. The purpose is to protect the client from financial liability associated with decontaminating equipment that arrived on the site with existing contamination. The decision regarding what must be surveyed will be made by the RSO. The degree of thoroughness of the survey and the requisite cleanliness of the equipment is at the discretion of the RSO.
2. Bring only the required equipment / supplies necessary for the task into the Restricted Area.

3. When practicable, use contamination prevention methods such as wrapping or sleeving of equipment taken into a CA or ARA.
4. Remove as much packaging material as possible (i.e., plastic or cardboard) prior to entering a Restricted Area.
5. Notify the RPT of any equipment / vehicles that need to be removed from a Restricted Area.

10.3 Visitor Escorts

1. Discuss planned activities, work locations, and site hazards with the Visitor. Discuss any restrictions on where the Visitor may go and what the Visitor may do within the Restricted Areas. Define the obligations of the Visitor with respect to following instructions of the escort and of safety personnel.
2. Provide the Visitor with a copy of the PESI Visitor Access Control Form (Attachment 1).
3. Instruct the Visitor to review the form, complete the top portion, and sign.
4. Answer any questions the Visitor may have. RP personnel are available to answer questions as needed.
5. Sign the PESI Visitor Access Control Form acknowledging escort responsibilities.
6. Obtain RSO and SSHO signature permitting Restricted Area access.
7. Give completed form to RP Personnel.
8. RP Personnel should assign a personnel dosimeter to the Visitor or group of visitors (this is a TLD unless otherwise instructed by the RSO). Note Self-Reading Dosimeter (SRD) in/out readings, if used, on the RWP Access Register.
9. Review the appropriate RWP with the Visitor, and ensure the Visitor dons PPE and signs and records the time of entry onto the RWP Access Register.
10. Escort the Visitor into the Restricted Area observing all escort responsibilities.
11. Upon completion of activities, assist visitor with PPE removal, and RWP sign-out. An RPT will perform the exit frisking.
12. Escort the Visitor out of the Restricted Area.
13. Take the personnel dosimeter and give it to the RP personnel. RP Personnel shall notify the RSO immediately if SRD readings indicate a personnel exposure.

11.0 ATTACHMENT

Attachment 1 PESI Visitor Access Control Form (FRONT & BACK)

ATTACHMENT 1
PESI VISITOR ACCESS CONTROL FORM (FRONT)

Name ______________________________ Representing ____________________________________

SSN _____ -_____ - _______ Mailing Address____________________________________ _____________

Some work at the PESI involves exposure to hazardous environments, radiation or radioactive materials. In keeping with the provisions of the Code of Federal Regulations Title 10, Part 19, this is to inform you of the extent of the hazards to which you may be exposed.

Radiation and radioactive materials on this project site are confined within clearly posted and delineated areas. Other hazardous materials may be present in these areas. Signs in these areas are magenta or purple and yellow in color and contain the international symbol for radiation, a trefoil or **three-bladed design. (ESCORT: SHOW VISITOR AN EXAMPLE OF A RADIOLOGICAL POSTING)**.

During your visit, you will be provided with an escort. You must remain with your escort at all times. In the unlikely event of an incident involving radioactive or other hazardous materials, your escort will provide you with instructions. Comply with the instructions of your escort. If exit frisking is required by the RWP, Radiation Protection Personnel will perform the exit frisk.

Do not enter any areas posted "RADIATION AREA" "HIGH CONTAMINATION AREA" or "AIRBORNE RADIOACTIVITY AREA."

Do not perform work of an intrusive nature (i.e., digging, drilling, sampling, etc.) or any abrasive work (i.e., welding, sanding, grinding, etc.) without specific written approval of the RSO.

Nuclear Regulatory Guide 8.13, "Instructions Concerning Pre-natal Radiation Exposure" is available for review upon request.

Address any questions you may have to your escort or to the person you are visiting. Questions may also be directed to the Safety & Health Department.

I have read and understand the above. I agree to comply with the terms of this form.

Visitor Signature **Date**

I have reviewed the above with the visitor and agree to comply in full with PESI established radiological escort protocols including, but not limited to, those specific requirements specified on the back of this form.

Escort Signature **Date**

Restricted Area Access Authorized:

RSO or designee Signature **Date**

SSHO or designee Signature **Date**

ALL SIGNATURES MUST BE PRESENT ON THIS FORM PRIOR TO RESTRICTED AREA ACCESS!

ATTACHMENT 1 (BACK OF FORM)
PESI VISITOR ACCESS CONTROL FORM

SSHO/RSO Requirements to Minimize or Eliminate Exposure Risks:

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____

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SSHO/RSO Remarks:

____

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SSHO Initials: __________ RSO Initials: ____________

TITLE:	Radiological Postings	NO.:	RP-102
		PAGE:	1 of 6
		DATE:	May 2014

APPROVED:

5/31/14

Technical Services Manager Date

5/31/14

Corporate Certified Health Physicist Date

1.0 PURPOSE

The purpose of this procedure is to provide consistent methodology for posting requirements for various radiological hazard areas on PESI Projects.

2.0 APPLICABILITY

This procedure applies to all which require radiological postings.

3.0 REFERENCES

1. 10 CFR 19, "Notices, Instructions, and Reports to Workers; Inspection."
2. 10 CFR 20, "Standards for Protection Against Radiation."
3. Perma-Fix Environmental Services (PESI) Radiation Protection Plan (RPP)

4.0 GENERAL

4.1 Discussion

Radiological postings are used to delineate areas containing radiological hazards and to inform personnel of hazards. In addition, supplemental or informational postings may be included which provide personnel with entry requirements or protective equipment requirements. Barriers may be used in conjunction with postings to ensure that personnel do not inadvertently enter into an area with a radiological hazard. Barriers at the PESI and the vicinity properties are normally composed of rope, tape, or fencing.

4.2 Definitions

Posting: A standardized sign or label which bears the standard trefoil radiation symbol in magenta or black on a yellow background and information concerning a specific radiological hazard.

5.0 RESPONSIBILITIES

5.1 Site Safety & Health Officer (SSHO)

- The SSHO is responsible for ensuring all activities performed within this procedure conform to the requirements of the SSHP.

5.2 Radiation Safety Officer (RSO)

- Implementation of this procedure.
- Reviewing pertinent survey data and making periodic tours to verify all areas within the PESI are properly posted.
- Authorizing the de-posting or down-posting of areas.
- Providing technical direction to the Radiation Protection Technicians (RPTs).

5.3 Radiation Protection Technician (RPT)

- Directing the placement of radiological postings and barriers.
- Performing periodic radiation / contamination surveys to ensure radiological conditions have not changed.

5.4 Project Supervisor

- Ensuring that personnel working in their particular area obey all radiological postings.

5.5 Project Personnel

- Obeying all radiological postings.
- Following directions from the RPT with regards to radiological postings.
- Maintaining their personnel exposures as low as reasonably achievable (ALARA).

6.0 PREREQUISITES

RPTs will be trained to assess and recognize the various radiological hazards present at the PESI.

7.0 PRECAUTIONS AND LIMITATIONS

- Barriers and other means shall be used as required to maintain control of areas requiring posting.
- At a minimum, all access / egress points to areas requiring radiological posting shall be conspicuously posted with the appropriate signs which includes area descriptions and specific requirements for entry.
- Appropriate signs should be placed approximately every 40 feet around the perimeter of a posted area. At least one sign should be placed on each side of an area's boundary, visible from any normal avenue of approach. These signs require only area identifiers (e.g., Restricted Area, Radioactive Materials Area, Radiation Area, etc.) in addition to the standard "Caution" or "Warning" and the tre-foil.
- An RPT with the appropriate field survey instrumentation may serve as the radiological posting in situations where the task is of a short duration or at the discretion of the RSO.
- No radiological control(s) shall be installed in any area that would prevent the rapid evacuation of personnel in an emergency situation.

- Trained emergency response personnel (Fire Dept, Ambulance / EMT, Law Enforcement) responding to on-site emergencies are exempt from the requirements of this procedure.
- Postings should be as clear and concise as possible to prevent confusion on the part of personnel desiring to enter an area.
- Postings should not be hung from ladders, electrical wire, switches, vehicles, or any other item that could be damaged, moved, or could cause injury to personnel.
- If more than one level of radiological posting is required in an area, posting for each unique condition shall be identified starting with the highest hazard potential. However, it is not required to post areas with area identifiers that are superceded by postings identifying a higher hazard potential (e.g., posting a Contamination Area as a Radioactive Materials Area, etc.).
- Radiological postings shall not be moved or altered without approval from the RSO or the RPT covering the work.

8.0 APPARATUS

- Yellow and magenta barrier supplies (e.g., rad-rope, rad-tape, rad-ribbon, etc.)
- Signs and inserts as required
- Radioactive Material Labels or tags
- Stands or Stanchions

9.0 RECORDS

All surveys performed for radiological posting placement will be forwarded to project document control.

10.0 PROCEDURE

10.1 Controlled Areas

All access points to areas meeting the definition of a Controlled Area shall be posted with the words “CONTROLLED AREA,” or “US GOVERNMENT PROPERTY” plus any additional verbiage deemed appropriate by Project Management.

10.2 Restricted Areas

All access points to areas meeting the definition of a Restricted Area shall be posted with the words “RESTRICTED AREA.”

10.3 Contamination Areas

All access points to areas meeting the definition of a Contamination Area shall be posted with the words “CAUTION, CONTAMINATION AREA,” and with the words “RESTRICTED AREA,” as well as any special instructions deemed necessary by the RSO.

10.4 High Contamination Areas

All access points to areas meeting the definition of a Contamination Area shall be posted with the words “CAUTION, HIGH CONTAMINATION AREA,” and with the words “RESTRICTED AREA,” as well as any special instructions deemed necessary by the RSO.

10.5 Radiation Areas

All access points to areas meeting the definition of a Radiation Area shall be posted with the words "CAUTION, RADIATION AREA" as well as any special instructions deemed necessary by the RSO.

10.6 High Radiation Areas

All access points to areas meeting the definition of a High Radiation Area shall be posted with the words "DANGER, HIGH RADIATION AREA" as well as any special instructions deemed necessary by the RSO.

10.7 Radioactive Materials Areas

All access points to areas meeting the definition of a Radioactive Materials Area shall be posted with the words "CAUTION, RADIOACTIVE MATERIALS AREA" as well as any special instructions deemed necessary by the RSO.

10.8 Airborne Radioactivity Area

All access points to areas meeting the definition of an Airborne Radioactivity Area shall be posted with the words "CAUTION, AIRBORNE RADIOACTIVITY AREA" as well as any special instructions deemed necessary by the RSO.

10.9 Posting / De-Posting / Down-Posting

Posting, De-posting, and Down-posting activities should be noted in the appropriate technician logbook with reference to applicable survey number(s).

11.0 ATTACHMENTS

None

	PERMA-FIX ENVIRONMENTAL SERVICES		
TITLE:	**Radiation Work Permits Preparation and Use**	**NO.:**	RP-103
		PAGE:	1 of 7
		DATE:	May 2014

APPROVED:

Technical Services Manager ________ Date 5/31/14

Corporate Certified Health Physicist ________ Date 5/31/14

1.0 PURPOSE

This procedure describes the conditions under which a Radiation Work Permit (RWP) is required on PESI Projects. This procedure establishes consistent methodology and responsibilities for developing, utilizing and terminating an RWP. The procedure also describes the functions of the RWP (a sample is given in Attachment 1).

2.0 APPLICABILITY

This procedure applies to RWP requests, preparation, use, and termination. All personnel working on a task for which a RWP is required are required to comply with its conditions.

3.0 REFERENCES

1. Title 17, California Code of Regulations, Section 30255, "Notices, Instructions and Reports to Workers, Inspections, and Investigations."
2. Title 17, California Code of Regulations, Division 1, Chapter 5, Subchapter 4 "Standards for Protection Against Radiation."
3. RP-101, "Access Control."

4.0 DEFINITIONS

Airborne Radioactivity Area: Means any area where the measured concentrations of airborne radioactivity above natural background exceed, or are likely to exceed, 25% of the Derived Air Concentration (DAC) values identified in Section 6.0 of the Radiation Protection Plan; and as listed in 10 CFR 20, Appendix B, Table I, Column 3

Contamination Area (CA): Means any area accessible to personnel with loose surface contamination values in excess of the values specified in the United States Army Corps of Engineers (USACE) Radiation Protection Manual, "Acceptable Surface Contamination Levels," (also refer to Table 1 of the Radiation Protection Plan; and procedure RPP-104, "Radiological Surveys,") or any additional area specified by the Radiation Safety Officer (RSO). The

Contamination Area posting requirement is more restrictive than the Radioactive Material Area posting requirement. Any area posted as a Contamination Area shall also be considered to be a Radioactive Materials Area.

Radiation Work Permit (RWP): Means a document or series of documents prepared by Radiation Protection to inform workers of the radiological and industrial hygiene conditions which exist in the work area and the radiological requirements for the job.

Radiation Area (RA): Means any area, accessible to personnel, where the whole body dose rate exceeds 5 mrem/hr but less than 100 mrem/hr at 30 cm from the source.

Radiological Area: Any area within a Restricted Area which require posting as a Radiation Area, Contamination Area, Airborne Radioactivity Area, High Contamination Area, or High Radiation Area.

High Radiation Area (HRA): Means any area accessible to personnel where the whole body dose rate exceeds 100 mrem/hr at 30 cm (12 inches) from the radiation source.

Radioactive Materials Area (RMA): Any area or room where quantities of radioactive materials in excess of 10 times the 10 CFR 20, Appendix C quantities are used or stored, or any area designated by the RSO which does not exceed the site Contamination Area criteria.

Restricted Area: Means any area to which access is limited by Project Management for the purpose of protecting individuals against exposure to radiation and radioactive materials.

5.0 RESPONSIBILITIES

5.1 Radiation Safety Officer (RSO)

- Implementation of this procedure.
- Approving all protective measures incorporated into the RWP with regards to Radiological Safety.

5.2 Radiation Protection Technician (RPT)

- Conducting radiation and contamination surveys and keeping legible records.
- Preparing RWPs to control access to and activities in radiological areas.
- Monitoring worker compliance with RWP requirements.

5.3 Project Personnel

- Reviewing the correct RWP for the task to be performed.
- Accurately and legibly completing required information on the RWP Access Register.
- Observing radiological postings.
- Obeying oral and written radiological and industrial hygiene control instructions and procedures, including instructions on RWPs.
- Maintaining an awareness of radiological and industrial hygiene conditions in the work area.

6.0 PREREQUISITES

1. A RWP shall be required for the following:
   - All tasks requiring entries into Radiological Areas.

- As specified by the RSO or their designees.

2. Prior to use of an RWP, the RSO or designee shall:
   - Define an access location appropriate for the RWP.
   - Review the inventory at the applicable Access Control Points and shall verify that Personal Protection Equipment (PPE), instruments and other safety-related equipment necessary to support the requirements of the RWP are available.
3. Prior to entry, all personnel working under an RWP must:
   - Satisfy medical and training requirements as established in the Access Control procedure.
   - Be adequately briefed by the Radiation Protection Group regarding:
     - Work to be performed and the associated RWP requirements.
     - Safety procedures to be followed for its completion.

7.0 PRECAUTIONS AND LIMITATIONS

- Personnel shall not deviate from the requirements, precautions, or other instructions on the RWP without authorization from the RSO or designees.
- A copy of the RWP shall be posted at the work site. The original shall remain at a central location (Safety and Health office). Associated support documents containing environmental conditions (soil activities, contamination surveys, etc.) shall be maintained by the RSO and are available upon request.
- An RWP is not required when responding to emergency situations where serious consequences could result if time were taken to prepare the RWP.

8.0 APPARATUS

None

9.0 RECORDS

- Hazardous Work Permit (RWP)
- Hazardous Work Permit Access Register

10.0 PROCEDURE

10.1 Active RWP Use

1. The RP group will activate the RWP upon review and signature by the RSO.
2. A copy of active RWPs will be maintained at applicable Access Control Points.
3. The RSO or designee shall review the inventory and shall verify that PPE, instruments and other safety-related equipment necessary to support the requirements of the RWP are available at the applicable Access Control Points. Inventory reviews shall also be performed, as necessary, during the course of work on the RWP.
4. All workers who will be working on tasks supported by an RWP will be provided an initial briefing on the RWP by a Safety and Health representative:

- Upon their entry on the RWP.
- Upon initial entry following revision of a RWP.
- When significant changes occur in the work area.

5. The purpose of the briefing is to ensure:
   - All Safety and Health conditions, requirements, special precautions, are fully understood by the workers.
   - Ensure that all anticipated tools, materials, and equipment are assembled for the work.
   - Ensure that work party members have been issued any radiological monitoring or protective devices specified for the work.
6. All personnel will read and verify that they understand and agree to comply with the terms of the RWP by signing in on the RWP Access Register (Attachment 2).
7. While working under an RWP, personnel are responsible to know and understand:
   - The tasks that fall under the RWP.
   - Procedural controls and precautions taken to:
     - Reduce spread of contamination.
     - Reduce airborne emissions of radionuclides.
     - Reduce dose to workers and the public as low as reasonably achievable (ALARA).
     - Requirements to apply the sound radiological and safe work practices taught in indoctrination and continuing training.
8. The RSO or the attending RPT have stop work authority for all phases of work under an RWP. Stop work authority can be implemented when personnel safety is jeopardized due to:
   - A change in the radiological (or other hazard) environment occurs, requiring additional controls and / or precautions.
   - If poor work practices are employed.
   - If RWP, ALARA, or procedural controls and / or precautions are violated.
9. Personnel shall sign in / out on the RWP Access Register for each entry into and egress from an area including when exiting the area for short break periods and when transferring to work on a different RWP.
10. Upon completion of work or at the end of the shift the Work Party Supervisor shall ensure that:
    - Access Control Point and Work Area conditions are satisfactory. This includes housekeeping, safe storage of equipment, ensuring any required contamination control measures are implemented, and accurate completion of RWP Access Registers.

- All radiological and Industrial Hygiene monitoring and protection devices that were issued have been returned to the Safety and Health (S&H) Group.

10.2 Termination of RWP

1. If the work was not or cannot be completed within the duration period of the RWP, an extension of the RWP should be requested.
2. An RWP is considered “terminated upon:
   - Signature by the RSO, or designee(s) in the appropriate section on the **original** RWP.
   - If the duration period for the RWP is been exceeded and the RWP was not extended.
3. Upon Completion of an RWP task, the Work Party Supervisor shall ensure that:
   - Access Control Point and Work Area conditions are satisfactory. This includes housekeeping, safe storage of equipment, ensuring any required contamination control measures are implemented, and accurate completion of RWP Access Registers.
   - All radiological and Industrial Hygiene monitoring and protection devices that were issued have been returned to the RP Group.
4. Upon completion of the job, the RWP copy and RWP Access register shall be returned to the RP Group for disposition.
5. Completed RWP forms (originals) and RWP Access Registers are quality records. These documents shall be maintained by the RP Group until transmitted to Project Records.

11.0 ATTACHMENTS

Note: Attachments may be revised without formal review of this procedure and are attached as examples only. Please contact the RSO for a current copy of these attachments.

Attachment 1 Radiation Work Permit (Typical)

Attachment 2 Radiation Work Permit Access Register (Typical)

Attachment 1 (Typical)

PESI RADIATION WORK PERMIT (RWP)

NO. ___ ___ ___ - ___ ___ ___

Revision Number ___

WORK DESCRIPTION:	WORK LOCATION(S):
	Start Date /Time:
	Est. Completion Date:
	Requested by:
	Request Date:

HAZARDOUS CONDITIONS

IS A RADIOLOGICAL / ALARA REVIEW REQUIRED ? No ☐ Yes ☐

I.H. LIMITS:	RADIOLOGICAL LIMITS	CURRENT CONDITIONS
O_2:	Exposure Rate:	*IH/Rad conditions are evaluated by Safety & Health personnel, as necessary, during job coverage. The adjacent IH/Rad limits are the maximum allowed by this RWP.*
LeL:	Alpha Contamination:	
Org. Vapors:		
DUST:	General Area Airborne:	
H2S:	Limiting Isotope / DAC Value:	

REQUIRED PERSONAL PROTECTIVE CLOTHING & EQUIPMENT (PPE)

HEAD / EYES	FEET / LEGS	BODY
☐ Hard Hat ☐ Safety Glasses ☐ Monogoggles ☐ Face Shield	☐ Sturdy Work Shoes ☐ Disposable Shoe Covers ☐ Rubber Over Shoes / Boots ☐ Other (Specify):	☐ Cotton Coveralls ☐ Tyvek Coveralls (Regular) ☐ Tyvek Coveralls (Coated) ☐ Other (Specify)
RESPIRATORY	**HANDS**	**MISCELLANEOUS**
☐ Full Face (Negative Pressure) * ☐ Powered Air Purifying* ** Specify Cartridge or Canister Type Below* ☐ Other (specify)	☐ Cotton / Work Gloves ☐ Nitrile Surgeons Gloves ☐ Rubber Gloves ☐ Other (Specify):	☐ Tape Gloves & Boots to Coveralls ☐ Fall Protection ☐ Hearing Protection ☐ Other (Specify)

ADDITIONAL REQUIREMENTS / SPECIAL INSTRUCTIONS / MONITORING REQUIREMENTS

Additional Requirements	Special Instructions
☐ "Buddy System" in Effect ☐ S&H Tech Job Coverage (Intermittent / Continuous) ☐ Confined Space Entry Permit ☐ HotWork Permit ☐ Lockout-Tagout Permit ☐ Excavation Permit ☐ Review MSDS ☐ Emergency Response Equipment ☐ Communication Method (Radio / Voice) ☐ Portable Eyewash Station ☐ Pre-Entry Monitoring ☐ S&H Tech Notification Prior to Work (Daily / Each Entry) ☐ Personnel Frisking Required (Whole-Body / Hand & Feet) ☐ ____________ ☐ ____________ ☐ ____________	

Dosimetry	Indiv.	Group
TLD Badge		
Extremity TLD		
Other (Specify):		

Air Monitoring	Indiv.	Group
Lapel-Breathing Zone		
Low Volume		
Dust		
PID / FID		
4 Gas		

Expiration Date/Time:

This permit will be reviewed for revision as conditions change and at 1-year from date of implementation.

APPROVALS	DATE	TERMINATION	DATE
RSO		RSO or SSHO	
SSHO		Reason:	

Attachment 2 (Typical)

PESI RWP ACCESS REGISTER

RWP # __ __ - __ __ __

WORK LOCATION: ______________________________ DATE: ___ ___ / ___ ___ / ___ ___ Sheet: ___ of ___

ENTRANT BADGE NUMBER (1)	ENTRANT SIGNATURE (2)	TIME IN (3)	TIME OUT	TIME IN	TIME OUT	TIME IN	TIME OUT	TIME IN	TIME OUT	TOTAL HOURS *(RP USE)*

Notes:

(1) If no badge number assigned, print name (Last, FI, MI)

(2) Entrant signature acknowledges understanding of and agreement to comply with RWP requirements, including required personnel monitoring. Entrants are to immediately report any frisker alarms or indications of personnel contamination to RP Personnel. **Escorts shall initial after entrant signature for visitors.**

(3) Use Military Time (24 Hour) for ALL entry/exit times (ex. 7:15 AM = 0715 or 3:25 PM =1525). Log each entry/exit, including break periods.

REGISTER REVIEW / DATA ENTRY: ________________________________

APPROVED:

5/31/14

Technical Services Manager Date

5/31/14

Corporate Certified Health Physicist Date

1.0 PURPOSE

This procedure establishes consistent methodology for performing radiation and contamination surveys at Perma-Fix Environmental Services (PESI) facilities and projects.

2.0 APPLICABILITY

This procedure is applicable to all personnel trained and qualified to perform radiation and contamination surveys at PESI.

3.0 REFERENCES

1. 10 CFR 20, "Standards for Protection Against Radiation."
2. PESI "Radiation Protection Plan (RPP)
3. RP-101, "Access Control."
4. RP-105, "Unrestricted Release of Requirements."
5. RP-106, "Survey Documentation and Review

4.0 GENERAL

4.1 Discussion

Radiological surveys are performed to detect and assess radiological conditions, which may be encountered at PESI.

4.2 Definitions

Contact Dose Rate: A radiation dose rate as measured at contact or within 1/2 inch of the surface being measured.

CPM: Counts per minute

Dose Rate: The quantity of absorbed dose delivered per unit of time.

DPM: Disintegrations per minute

General Area Dose Rate (GA Dose Rate): The highest radiation dose rate accessible to any portion of the whole body measured at a distance of 30 cm (12 inches) from a significant radiation source or combination of sources.

LAW: Large area Wipe (i.e., Masslinn)

MDA: Minimum Detectable Activity

Survey: An evaluation of the radiation hazards incident to the production, use, release, disposal, or presence of radioactive materials or other sources of ionizing radiation under a specific set of conditions.

5.0 RESPONSIBILITIES

5.1 Radiation Safety Officer (RSO)

- Implementation of this procedure.
- Ensuring appropriate radiation surveys are performed to measure and document radiation levels.
- Ensuring all completed surveys are adequately reviewed.
- Providing technical direction to the RPTs.

5.2 Radiation Protection Technician (RPT)

- Conducting and documenting radiation surveys.
- Performing all necessary pre / post use operability checks.
- Creating neat, legible, and concise records.

6.0 PREREQUISITES

- Prior to performing a radiation survey, personnel should review previous survey data and familiarize themselves with possible radiological hazards.

7.0 PRECAUTIONS AND LIMITATIONS

- Personal Protective Equipment (PPE) should be appropriate for the level of contamination expected and shall be in compliance with Site Safety & Health Plan (SSHP), Radiation Work Permits (RWPs), or other work specific controlling documents. At a minimum, gloves or tweezers should be used when handling swipes.
- Direct probe surveys may be used to demonstrate compliance with removable limits given in Attachment 1 (Acceptable Surface Contamination Levels), and discussed in RPP-105, "Unrestricted Release of Requirements." When instrumentation is used in this manner it should be capable of achieving the removable minimum detectable count (MDC) requirements.
- Surface contamination limits are contained in Attachment 1.
- Instruments used in surveys should be capable of achieving a Minimum Detectable Activity (MDA) that is less than the applicable release limits.
- In high background areas it may not be possible to achieve the required survey MDAs for beta / gamma instruments.

8.0 APPARATUS

- Radiation and contamination survey instruments

- Smears
- Masslinn
- Personal Protection Equipment

9.0 RECORDS

Survey documentation to be completed per RPP-106, "Survey Documentation and Review."

10.0 PROCEDURE

10.1 General Instructions

1. Select the survey instrument based on the anticipated hazards and dose rates as determined by a review of previous survey data and ongoing work activities.
2. Perform pre-operational and response checks in accordance with the operating procedures for the instrument.
3. Remove any defective instrument from service.
4. Obtain survey forms and any other material required to document survey results.
5. Contamination Surveys are normally done for alpha emitting constituents. In certain circumstances the RSO can dictate that a survey be performed for both alpha and beta emitting constituents.

10.2 Routine Survey Frequencies

1. The RSO shall specify areas for routine monitoring surveys and the frequency of such surveys. The RSO should maintain a routine survey frequency schedule. The schedule is NOT considered a record, and does not need to be retained.
2. The following areas should be considered for a routine survey on a DAILY basis:
   - Access Control Points.
   - Designated eating, drinking, and smoking areas within Restricted Areas.
   - Radiological Counting Labs and sample prep areas.
   - Any other area specified by the RSO.
3. The following areas should be considered for a routine survey on a WEEKLY basis:
   - High Traffic areas on the PESI Site.
   - Operating high-efficiency particulate air (HEPA) exhaust areas.
   - Highly occupied areas within the radioactive Materials Area that could be a source of personnel contamination or an intake of radioactive materials (e.g., the boot change area, equipment floorboards, and workshops).
4. The following areas and equipment should be considered for a routine survey on a MONTHLY basis:
   - Occupied offices.
   - Storage areas.

- Occupied areas within the radioactive Materials Area that could be a source of personnel contamination or an intake of radioactive materials (e.g., equipment storage areas).

5. The following should be done on an as-needed basis:

   - Incoming Surveys

     The RSO can direct that incoming surveys be performed on equipment and materials arriving onto the site. The purpose of an incoming survey is to protect the client from financial liability associated with decontaminating equipment that arrived on the site with existing contamination. The degree of thoroughness of the survey and the requisite cleanliness of the equipment is at the discretion of the RSO.

   - Surveys of Materials Vehicles, and Personnel leaving Restricted Areas

     All materials, vehicles, and personnel shall perform surveys upon leaving Restricted Areas that have a potential for spread of contamination. The RSO or designee can direct that additional surveys be performed as needed to monitor for spread of contamination.

- Direct Total Contamination Surveys
  1. All items being surveyed should appear to be clean prior to being surveyed. To the extent possible, all interior and exterior surfaces should be free from oil and visible dirt. The RSO may dictate the required degree of cleanliness, based on the purpose of the survey and the history of the item being surveyed.
  2. Obtain proper instrumentation for the survey. Ensure that the instruments are currently calibrated and have been performance checked prior to the survey.
  3. Determine and record the background count in the area to be surveyed. Ensure that the background is representative of the measurement to be taken. Calculate and record the MDA on the appropriate survey form. Verify the MDA has been calculated for the background at the point of use and is less than the applicable site release criteria. In no case shall the background count time be less than the sample count time.
  4. Perform a scanning survey of the item. Concentrate survey measurements on areas most likely to be contaminated. The fraction of the total area scanned is subjective, based on technician experience, an item’s use history, and RSO guidance. Typically, the scan frequency is a minimum of 10% of accessible surface areas.
  5. Obtain static measurements at locations with the highest potential for contamination. The number of survey points selected is subjective, based on technician experience, an item’s use history, and RSO guidance. The count time should be consistent with the MDA calculation. A typical count times is one minute for digital scalers and until the meter reading stabilizes for analog ratemeters.

6. Record and identify all locations surveyed on the appropriate survey form(s). The use of diagrams or sketches is recommended.

   - **Beta-Gamma Probe** - In high background areas it may not be possible to achieve the required survey MDAs. This should be noted on the survey cover sheet, and should be brought to the attention of the RSO.
   - **Alpha Probe** - The performance check background may be used in place of background count in the area to be surveyed. A good practice is to check the probe for light leaks or for faulty cables if positive results begin appearing.

7. All measurements shall be reported in units of "dpm" unless otherwise directed by the RSO. Examples include "dpm/100 cm²," and "dpm/probe."

8. Direct non-smearable hot spots may be averaged over 1 square meter to determine compliance with release levels. If the entire item is less than 1 square meter in area, the entire surface area may be averaged. Bolt on parts of a vehicle should not be considered separate items.

   - The method for determining an average activity is to mark a 1 square meter area on the piece to be surveyed that is roughly centered on the hot spot. Take 1 measurement at the highest activity point of the hot spot. Take 4 (or more) other measurements within the square meter at locations representative of the whole square meter. Record count-rate of each individual measurement. Calculate the activity of all measurements being averaged, including those that are less than the MDA and those with a calculated activity less than zero. Calculate the average of all measurements and record on the survey form.

9. Complete the appropriate survey form.

10.3 Removable Contamination

With RSO approval, removable contamination surveys may be disregarded, provided that direct survey measurements and instrument MDAs are below site removable contamination limits for release.

1. All items being surveyed shall be clean prior to being surveyed. All interior and exterior surfaces should be free from oil and visible dirt. The RSO may dictate the required degree of cleanliness, based on the purpose of the survey and the history of the item being surveyed.

2. Wipe each location of interest with moderate pressure area using a standard 1 ¾-inch swipe. The area wiped should be approximately 100 cm². Larger areas may be wiped. It can be inferred that if the wipe meets the required limit for 100 cm² when it was actually taken from a larger area, the object will pass the 100 cm² criteria. No special documentation is required if the wiped area exceeds 100 cm². If the object is smaller than 100 cm², the area of the entire object should be wiped.

3. Large area wipes (LAW), also commonly referred to by the trade name "Masslinn" may be used to <u>supplement</u> smear surveys for removable

contamination. The use of LAWs should be documented on the survey form with the notation "LAW," or equivalent.

4. Ensure each used swipe (i.e., smear or large area wipe) is handled, stored, and transferred in such a fashion as to prevent to loss of sampled material or cross-contamination with other personnel and other swipe samples.
5. Record the location of each wipe on the appropriate survey form. It is preferable to record the location by circling the sequential number location on a survey map where the wipe was taken.

10.4 Analyzing Swipes

1. Smear samples should be counted using available scintillation or gas-flow proportional laboratory counters, when practicable. Field instruments may be used for smear counting at the discretion of the RSO.
2. LAW samples may be counted using field instruments. The use of laboratory counters is inappropriate.
3. Determine and record the background count-rate. Calculate and record the MDA on the appropriate survey form. Verify the MDA has been calculated for the background at the point of use and is less than the applicable site release criteria. In no case shall the background count time be less than the sample count time.
4. Remove each swipe from the paper backing, as needed. The use of tweezers is recommended.
5. Place the swipe in the counter and close.
6. Count for the designated counting time.
7. Record the gross result under cpm in the appropriate column (either alpha or beta-gamma) of the survey form.
8. Calculate and record the activity. Removable contamination survey results shall be reported in units of "dpm" unless otherwise directed by the RSO. Examples include "dpm/100 cm^2" and "dpm/LAW."

10.5 Gamma Surveys

1. Routine gamma surveys may be used to detect the gradual buildup of gamma emitting contaminated materials in soils. This may occur at heavy equipment, heavy traffic, or egress points from contaminated areas. Normal uncontaminated trash should be gamma surveyed prior to leaving the site.
2. Obtain proper instrumentation for the survey. Ensure that the instruments are currently calibrated and have been performance checked prior to the survey.
3. Perform the survey with the appropriate detector using techniques specified by the RSO.
4. Complete the appropriate survey form.

10.6 Gamma Dose Rate Surveys

- Obtain proper instrumentation. Ensure that the instrument is currently calibrated and has been performance checked prior to the survey.

- When entering areas with known radiation levels, select the appropriate scale.
  - Observe the meters as you enter the area. If necessary, change scales to maintain on-scale reading.
- Perform gamma dose rate surveys as follows:
  - Monitor dose rates from the lower thighs to head level, recording the highest level as General Area Dose Rate.
  - Monitor dose rates 30 cm (12 inches) from a significant radiation source recording the highest level as General Area Dose Rate.
  - Additional measurements are necessary to determine Transport Index for shipping per procedure PP-8-810, "Conveyance Survey."
  - If dose rate sources are predominantly from overhead, then denote on survey.
  - Perform contact gamma dose rate measurements with the detector within ½-inch of the surface to be surveyed.
  - Additional measurement locations should be clearly identified in survey documentation.
  - Record all survey results on the appropriate survey form.

11.0 CALCULATIONS

11.1 Sample Activity

$$\frac{DPM = \left(\dfrac{TotalSampleCounts}{SampleCountTime}\right) - \left(\dfrac{TotalBkgCounts}{BkgCountTime}\right)}{(E)\ (A)}$$

where:

E = Instrument Efficiency
A = Area correction factor, if applicable

11.2 Minimum Detectable Activity (MDA)

The following MDA equation is to be used for a background count time equal to the sample count time:

$$MDA = \left(\frac{(3 + 4.65\sqrt{B}\ )}{(E)(A)(T_S)}\right)$$

where:

Ts = Sample count time
E = Instrument efficiency

A = Area correction factor, if applicable
B = Background cpm

The following equation is to be used for a background count time equal to 5 or more times the sample count time:

$$MDA = \left(\frac{(3 + 3.29\sqrt{B})}{(E)(A)(T_S)} \right)$$

12.0 DOCUMENTATION

- Survey forms shall be completed in entirety. This includes attaching printouts, diagrams, or other supporting documentation, appending sequential page and survey tracking numbers, a review for completeness and accuracy, and appending the appropriate signatures of personnel performing the survey and / or analyzing samples.
- Once complete, the survey package shall be submitted to the RSO or designee, for final review and approval signature.
- Survey documentation shall be maintained according to established RP document control and retention requirements.

13.0 ATTACHMENT

Attachment 1 Acceptable Surface Contamination Levels

Attachment 1

Acceptable Surface Contamination Levels

NUCLIDE[a]	AVERAGE[b c] dpm/100 cm^2	MAXIMUM[b d] dpm/100 cm^2	REMOVABLE[b e] dpm/100 cm^2
U-nat, U-235, U-238 and associated decay products	5,000	15,000	1,000
Transuranics, Ra-226, Ra-228, Th-230, Th-228, Pa-231, Ac-227, I-125, I-129	100	300	20
Th-nat, Th-232, Sr-90, Ra-223, Ra-224, U-232, I-126, I-131, I-133	1,000	3,000	200
Beta-gamma emitters (nuclides with decay modes other than alpha emission or spontaneous fission) except Sr-90 and others noted above.	5,000	15,000	1,000

Notes:

[a] Where surface contamination by both alpha- and beta-gamma-emitting nuclides exists, the limits established for alpha- and beta-gamma-emitting nuclides should apply independently.

[b] As used in this table, dpm means the rate of emission by radioactive material as determined by correcting the counts per minute observed by an appropriate detector for background, efficiency, and geometric factors associated with the instrumentation.

[c] Measurements of average contaminant should not be averaged over more than 1 square meter. For objects of less surface area, the average should be derived for each object.

[d] The maximum contaminated level applies to an area of not more than 100 cm^2.

[e] The amount of removable radioactive material per 100 cm^2 of surface area should be determined by wiping that area with dry filter or soft absorbent paper, applying moderate pressure, and assessing the amount of radioactive material on the wipe with an appropriate instrument of known efficiency. When removable contamination on objects of less surface area is determined, the pertinent levels should be reduced proportionally and the entire surface should be wiped.

*Source: USCG / USEPA EM 385-1-80 Table 6-4 Acceptable Surface Contamination Levels, 1985.

Note: The acceptable surface contamination levels for Th-nat will be used unless subsequent sampling indicate the presence Ra-226, Ra-228, Th-230, Pa-231, or Ac-227 in concentrations greater than that of the parent nuclide. The RSO will determine if contamination limits should be modified for a specific activity or location based on available data.

APPROVED:

Technical Services Manager — Date 5/31/14

Corporate Certified Health Physicist — Date 5/31/14

1.0 PURPOSE

This project procedure describes the method of surveying equipment, materials, or vehicles for release for unrestricted use at Perma-Fix Environmental Services (PESI) facilities and projects.

2.0 APPLICABILITY

This project procedure applies to all site personnel responsible for the unrestricted release of equipment and materials used in a Restricted Area. This procedure is not used for vehicles that are transporting radioactive materials. Vehicles conveying radioactive materials also must follow USDOT Regulation 49 CFR Part 173.

3.0 REFERENCES

1. Title 17, California Code of Regulations, Division 1, Chapter 5, Subchapter 4 "Standards for Protection Against Radiation."
2. PESI "Radiation Protection Plan (RPP)
3. NRC Regulatory Guide 1.86.
4. RP-104, "Radiological Surveys"

4.0 DEFINITIONS

CPM: Counts per minute

DPM: Disintegrations per minute

Equipment and Material: Equipment and material refers to any item used in a Restricted Area to support work activities (i.e., hand tools, heavy equipment, plastic, etc.).

LAW: Large Area Wipe (i.e., Masslinn)

Unrestricted Release: Release of equipment and / or material to the general public.

5.0 RESPONSIBILITIES

5.1 Radiation Safety Officer (RSO)

- Ensuring adequate staffing, facilities, and equipment are available to perform the survey tasks assigned to Radiation Protection personnel.
- Approving purchase or acquisition of equipment necessary to perform surveys.
- Ensuring that surveys take place in appropriately posted areas.
- Reviewing results of survey data as required to determine acceptability for release of items.
- Dispositioning materials that cannot be released based on survey results.
- Investigating and initiating corrective actions for the improper release of radiologically contaminated material.

5.2 Radiation Protection Technician (RPT)

- Identify equipment and material to be surveyed for unrestricted release.
- Performing and documenting contamination surveys.
- Posting, securing and controlling radioactive material that cannot be released.
- Releasing material in accordance with this and implementing procedures.

5.3 Project Personnel

- Adhering to all policies, procedures and other instructions, verbal and written, regarding control and minimization of radioactive material and contaminated material.
- Reporting any concerns about the control and minimization of radioactive material and contaminated material to supervision.
- Maintaining good housekeeping at work sites and assisting in preventing the build-up and spread of contamination.

6.0 EQUIPMENT AND MATERIAL

- Alpha Detector
- Beta-Gamma Detector
- Portable Ratemeter / Scaler
- Scintillation or Gas-Flow Proportional Lab Alpha / Beta Counter
- Survey forms
- Cloth smears
- Masslinn™ type cloths

7.0 INSTRUCTIONS

7.1 General Instructions

Prior to conducting any surveys, ensure that all survey instrumentation has been response checked, is in operating within control limits and has not been removed from service.

- Response checks shall be performed daily.
- Background measurements are to be taken prior to use at the point of use. The background count time shall be greater than or equal to the sample count time.

- Verify that the MDA has been calculated for the background at the point of use and is less than the applicable site release criteria. Refer to RPP-104, "Radiological Surveys," for the MDA calculation.
- Survey results are converted from counts per minute (cpm) to disintegrations per minute (dpm). A sample "cpm to dpm" calculation is attached for review and use at the end of this procedure.

7.2 Release of Items for Unrestricted Use

1. Surveys for both total and removable contamination shall be made in accordance with Section 7.3 (below) on all equipment, materials or vehicles which have either been in a Restricted Area or which may be potentially contaminated.
2. With RSO approval, removable contamination surveys may be disregarded, provided that direct survey measurements and instrument MDAs are below site removable contamination limits for release.
3. RP personnel will determine which items located outside a Restricted Area may be potentially contaminated based on their use, site history, or previous survey data. The potential for these objects to have become contaminated by airborne radioactive materials must be considered. This could include items that are used to support site activities, such as office equipment, cleaning devices, furniture, trailers, etc., even though direct contact may not have occurred.
4. Items which have a potential for internal contamination of inaccessible surfaces shall be evaluated by the RSO or designee prior to release.
5. All items to be released shall be surveyed in such a manner as to fully demonstrate that accessible surfaces comply with the surface contamination release criteria specified in RP-104, "Radiological Surveys."
6. Items that do not meet release criteria shall be decontaminated until release criteria is met or shall be disposed of as radiological waste.
7. Air intakes / filters on motorized equipment should be surveyed as an indicator of potential internal contamination. Notify the RSO or designee if air intake / filter surfaces indicate the presence of contamination. Contaminated air filters shall be removed and disposed of as radiological waste.
8. To the extent practicable, visible dirt and mud or other material shall be removed from surfaces prior to survey.
9. The RSO or designee, shall review all survey data prior to the release from the Controlled Area.

7.3 Direct Surveys Scans and Static Measurements

1. Surfaces shall be dry and cleaned, to the extent practicable prior to performing direct alpha measurements.
2. The RSO may authorize the short-term relocation or staging of equipment / vehicles for direct measurements in any portion of the Controlled Area. This is provided that the item has been verified to be clean of removable

contamination prior to removal from a Restricted Area and fixed contamination producing general area dose rates greater than 0.2 mrem/hr is not anticipated.

3. Alpha detectors should be placed within ¼-inch of the surface to be surveyed. Beta detectors should be placed within ½-inch of the surface to be surveyed. Use caution to not contaminate or damage the detector surface.
4. Perform a scanning survey of the item. Concentrate survey measurements on areas most likely to be contaminated. The fraction of the total area scanned is subjective, based on technician experience, an item's use history, and RSO guidance. Typically, the scan frequency is a minimum of 10% of accessible surface areas.
5. Obtain static measurements at locations with the highest potential for contamination. The number of survey points selected is subjective, based on technician experience, an item's use history, and RSO guidance.
6. Static measurement count times shall be appropriate for desired MDAs. Typical count times are one minute for digital scalers and until the meter reading stabilizes for analog ratemeters.
7. Record and identify all locations surveyed on the appropriate survey form(s). The use of diagrams or sketches is recommended.
8. All measurements shall be reported in units of "dpm" unless otherwise directed by the RSO. Examples include "dpm/100 cm^2" and "dpm/probe."

7.4 Removable Contamination Surveys

1. "Cloth" smears shall be used for smear surveys.
2. A notation (e.g., smear number, date, time, location, etc.) should be made on the smear envelopes to ensure proper smear tracking. Smears may also be numbered using a pen or marker prior to use.
3. Using moderate pressure, swipe an area of 100 cm^2 (4-inch square area or equivalent) of the surface at the selected location. Smear surveys should be performed at the same location that direct surveys were performed.
4. Large Area Wipes (LAW), also commonly referred to by the trade name "Masslinn," may be used to <u>supplement</u> smear surveys for removable contamination. The use of LAWs should be documented on the survey form with the notation "LAW" or equivalent.
5. Ensure each used swipe (i.e., smear or large area wipe) is handled, stored, and transferred in such a fashion as to prevent to loss of sampled material or cross-contamination with other personnel and other swipe samples.
6. Smear samples should be counted using available scintillation or gas-flow proportional laboratory counters, when practicable. Field instruments may be used for smear counting at the discretion of the RSO.
7. LAW samples may be counted using field instruments. The use of laboratory counters is inappropriate.
8. Removable contamination survey results shall be reported in units of "dpm" unless otherwise directed by the RSO. Examples include "dpm/100cm^2" and "dpm/LAW."

9. Ensure all results are documented on the appropriate survey form. Lab printouts may be attached and referenced on the survey form.

8.0 CALCULATIONS

MDA and Sample Activity formulas are located in RPP-104, "Radiological Surveys."

9.0 DOCUMENTATION

- Survey forms shall be completed in entirety. This includes attaching printouts, diagrams, or other supporting documentation, appending sequential page and survey tracking numbers, a review for completeness and accuracy, and appending the appropriate signatures of personnel performing the survey and / or analyzing samples.
- Once complete, the survey package shall be submitted to the RSO or designee, for final review and approval signature.
- Survey documentation shall be maintained according to established RP document control and retention requirements.

10.0 ATTACHMENT

None

PERMA-FIX ENVIRONMENTAL SERVICES		
TITLE: Survey Documentation and Review	NO.:	RP-106
	PAGE:	1 of 6
	DATE:	May 2014

APPROVED:

5/31/14
Technical Services Manager Date

5/31/14
Corporate Certified Health Physicist Date

1.0 PURPOSE

This procedure establishes consistent methodology for documenting radiological surveys and provides criteria for the review of these surveys.

2.0 APPLICABILITY

This procedure is applicable to all radiological surveys excluding air samples.

3.0 REFERENCES

1. 10 CFR 20, "Standards for Protection Against Radiation."
2. PESI "Radiation Protection Plan (RPP)
3. RP-104, "Radiological Surveys."

4.0 GENERAL

4.1 Discussion

The results of surveys will be documented on survey forms or in designated logs as approved by the Radiation Safety Officer (RSO). Survey data will contain enough detail to provide personnel with adequate information concerning radiological conditions existing in the area surveyed.

The RSO or designee will review completed survey documentation to ensure appropriate, adequate and complete information is recorded. The individual reviewing the survey will ensure that the recorded results are legible, in accordance with Radiological Protection Program (RPP) implementing procedures, consistent with anticipated levels, and will determine the reason for any variances.

4.2 Definitions

Airborne Radioactivity Area (ARA): Means any area where the measured concentrations of airborne radioactivity above natural background exceed, or are likely to exceed, 25% of the Derived Air Concentration (DAC) values listed in 10 CFR 20, Appendix B, Table I, Column 3.

Contamination Area (CA): Means any area accessible to personnel with loose surface contamination values in excess of the values specified in RP-104 , "Radiological Surveys, or any additional area specified by the Radiation Safety Officer (RSO). The Contamination Area posting requirement is more restrictive than the Radioactive Material Area posting requirement. Any area posted as a Contamination Area shall also be considered to be a Radioactive Materials Area.

Contact Dose Rate: A radiation dose rate as measured at contact or within 1/2 inch of the surface being measured.

General Area Dose Rate (GA Dose Rate): The highest radiation dose rate accessible to any portion of the whole body measured at a distance of 30 cm (12 inches) from a significant radiation source or combination of sources.

Radiation Work Permit (RWP): Means a document or series of documents prepared by Radiation Protection to inform workers of the radiological and industrial hygiene conditions, which exist in the work area and the radiological requirements for the job.

Radiation Area (RA): Means any area, accessible to personnel, where the whole body dose rate can exceed 5 mrem in 1 hour at 30 cm from the source.

Radioactive Material: Material activated or contaminated by the operation or remediation activities and by-product material procured and used to support the operations.

Radioactive Materials Area (RMA): Any area or room where quantities of radioactive materials in excess of 10 times the 10 CFR 20, Appendix C quantities are used or stored, or any area designated by the RSO which does not exceed the site Contamination Area criteria.

Radiological Area: Any area within a Restricted Area which require posting as a Radiation Area, Contamination Area, Airborne Radioactivity Area, High Contamination Area, or High Radiation Area.

Restricted Area: An area to which access is limited to protect individuals against undue risks from exposure to radiation, radioactive materials, and chemical contaminants. All posted radiological or chemical areas are Restricted Areas.

5.0 RESPONSIBILITIES

5.1 Radiation Safety Officer (RSO)

- The Radiation Safety Officer (RSO) or designee is responsible for reviewing radiological surveys performed by Radiation Protection Technicians (RPT).

5.2 Radiation Protection Technician (RPT)

- RPTs are responsible for documenting surveys in a legible manner on approved forms.

6.0 PREREQUISITES

- Surveys for radiation and contamination have been performed in accordance with RP-104 "Radiological Surveys".

7.0 PRECAUTIONS AND LIMITATIONS

- Surveys for airborne radioactivity will be documented in accordance with RP-107, "Measurement of Airborne Radioactivity."

8.0 APPARATUS

Survey Forms

9.0 RECORDS

- PESI Survey Form (Attachment 1)
- PESI Survey Log Number Form (Attachment 2)
- Radiation Protection Technician (RPT) Logbooks

10.0 PROCEDURE

The methods outlined in this procedure are intended to assure the clear and concise transfer of survey information. Variations or deviations from the protocols in this procedure are permitted if the clear transfer of information is maintained.

10.1 Documentation

10.1.1 General

1. Record all information on survey forms in a neat and legible manner.
2. Document all surveys on a form with approved project heading. Technician logbooks may be used for documenting surveys (e.g., daily routines, material transfers, minor posting changes, etc.) as authorized by the RSO and providing instrument serial numbers are documented with survey data.
3. When recording information on survey forms, check all appropriate boxes and circle all appropriate answers.
4. Use a survey form with pre-drawn diagrams when available. If not, draw a diagram or picture of the object surveyed. Should a diagram not be appropriate, use a lined survey form.
5. Assign the next sequential survey number to the survey from the survey number logbook.
6. Complete the following information for all surveys:
    - Date and time of survey
    - Location of survey
    - Instrument type and serial numbers and associated supporting information (i.e., detector efficiencies, calibration dates, background values, etc.)
    - HWP number, if applicable
    - Reason for survey

- Name and signature of surveyor

7. Indicate Radiological Hazard Area boundaries on the survey form using x's and -'s (-x-x or **).
8. Note the posted Radiological Hazard using common designator such as
   - Contamination Area = CA
   - Radiation Area = RA
   - Radioactive Material Area = RMA
   - Airborne Radioactivity = ARA
9. The use of Greek alphabet and other nuclear industry standard nomenclature (e.g., "k" = 1000) is acceptable when documenting surveys.

10.1.2 Survey Log Number Book:

1. Survey log number book is to be used to assign a unique sequential number to each survey form package. This number provides the ability to track individual surveys as well as ensuring the submittal of a complete documentation package for archiving.
2. Unless otherwise directed by the RSO, survey numbers will be assigned with the following format:

   NFSSyyRS.xxxx

   "NFSS" corresponds to "Niagara Falls Storage Site, " yy is the last two digits in the year, "RS" refers to "Radiological Survey," and xxxx refers to the sequential survey number.
3. As surveys are generated, the RPT will take the next sequential number on the form and fill in the remaining boxes with a brief description of the reason for the survey as well as the date and RPT's initials.

10.1.3 Radiation Surveys

1. Indicate GA dose rates by underlining the radiation level on the Survey Form at the appropriate location (Example: <u>25</u> uR/hr).
2. Indicate CONTACT dose rates by recording the radiation level with an asterisk on the Survey Form at the appropriate location (Example: * 25 ur/hr). If there are corresponding 30 cm and GA readings, document them as follows:

   * CONTACT / @ 30 cm / GA
3. Use a legend to inform the reviewer of any other notation utilized or if deviating from standard protocol.

10.1.4 Contamination Surveys

1. Indicate survey locations by placing sequential numbers within a circle on the Survey Sheet. The Survey Sheet has corresponding direct and transferable columns for both alpha and beta / gamma activity.
2. Use a legend to inform the reviewer of any other notation utilized or if deviating from standard protocol.
3. The use of the letter "k" to indicate units of a thousand is acceptable.

10.2 Technician Review and Evaluation

10.2.1 After completing the surveys, evaluate the results against previous surveys or anticipated results.

10.2.2 Verify that radiological boundaries and postings are correct in accordance with RPP-102, "Radiological Posting Requirements."

10.2.3 Take any immediate actions required based on survey results.

10.2.4 Ensure all relevant supporting documentation (e.g., count room print-outs, etc.) are attached to the survey package and that the package is properly paginated.

10.2.5 Submit documentation to the RSO or designee for supervisory review.

10.3 Supervisory Review

10.3.1 Ensure that the survey form is complete and legible.

10.3.2 Ensure that all required information has been completed.

10.3.3 Ensure that any changes, single line cross-outs, or deletions are initialed and dated at time performed.

10.3.4 Verify that results are consistent with those anticipated.

10.3.5 If results are not consistent, ensure that appropriate actions have been taken to explain the results or re-examine the area.

10.3.6 Sign-off in the appropriate review section of the survey form and submit package to RP Document Control for retention / transmittal to Project Files.

11.0 ATTACHMENTS

Note: Attachments may be revised without formal review of this procedure and are attached as examples only. Please contact the RSO for a current copy of these attachments.

Attachment 1 PESI Survey Form (Typical)

Attachment 2 PESI Survey Log Number Form (Typical)

Attachment 1 (Typical)

FUSRAP Survey Data Sheet

Survey No.:		**Item Surveyed:**		**Project:**	
Date:		**Contaminant/Limits:**			
Survey Tech.:		**Comments:**			
Count Rm. Tech.:					
Date Counted:					
Survey Type:					
Level of Posting:					

Notes:

ACF = Area Correction Factor
T_b = Background Count Time
T_s = Sample Count Time
R_b = Bkgd count rate
**Bcpm = Background cpm = R_b

Direct
(dpm) = (cpm - Bcpm)/(eff * ACF)

Removable
(dpm) = (cpm - Bcpm)/ eff
* dpm readings are per 100cm²

Parameters	*Rate*	*Gamma*	*Corr uR*	*Total* Alpha	*Total* Beta-Gamma	*Removable* Alpha	*Removable* Beta-Gamma
Instrument Model:							
Instrument SN:							
Cal. Due Date:							
x, y int.: *Efficiency:*	N/A						
BKG: *Bcpm**:*			N/A				
ACF:							
tB:							
tS:							
Lc:							
MDC:							

No.	*Descriptions*	*x*	*y*	*z*	*uR/hr*	*cptm*	*uR/hr*	*cpm*	**dpm*	*cpm*	**dpm*	*cpm*	**dpm*	*cpm*	**dpm*

Attachment 2 (Typical)

FMSS SURVEY TRACKING LOG (2002)

Survey No.	Survey Date	Item/Area Surveyed	Project #

<table>
<tr><td colspan="3">PERMA-FIX ENVIRONMENTAL SERVICES</td></tr>
<tr><td rowspan="3">TITLE: Measurement of Airborne Radioactivity</td><td>NO.:</td><td>RP-107</td></tr>
<tr><td>PAGE:</td><td>1 of 12</td></tr>
<tr><td>DATE:</td><td>May 2014</td></tr>
<tr><td colspan="3">APPROVED:

________________________ 5/31/14
Technical Services Manager Date

________________________ 5/31/14
Corporate Certified Health Physicist Date</td></tr>
</table>

1.0 PURPOSE

This procedure establishes the basis and methodology for the placement and use of air monitoring equipment, as well as the collection, analysis, and documentation of air samples. Radiological air sampling and analysis is performed to monitor concentrations of radionuclides in the air for purposes of tracking internal radiation exposure to occupational radiation workers, determining appropriate respiratory protection devices, establishing radiological posting boundaries, verifying effluent airborne radioactivity concentrations, and providing information on radiological conditions in the work area.

2.0 APPLICABILITY

This procedure applies to all radiological air monitoring activities performed in support of Perma-Fix Environmental Services (PESI) activities.

3.0 REFERENCES

1. Title 17, California Code of Regulations, Division 1, Chapter 5, Subchapter 4 "Standards for Protection Against Radiation."
2. Perma-Fix Environmental Services (PESI), "Radiation Protection Plan (RPP)
3. Rock, R.L., *Sampling Mine Atmospheres for Potential Alpha Energy Due to the Presence of Radon-220 (Thoron) Daughters*, Informational Report No. 1015, United States Department of the Interior, Mining Enforcement and Safety Administration, 1975.
4. Kusnetz, H.L., Radon Daughters in Mine Atmospheres, A Field Method for Determining Concentrations, Am. Ind. Hyg. Assoc. Quat., Vol. 17, No. 87, 1956.
5. ANSI N13.1, Guide to Sampling Airborne Radioactive Materials in Nuclear Facilities.
6. Regulatory Guide 8.25, Air Sampling in the Workplace.
7. 29 CFR 1910.1096, United States Occupational Health & Safety, Ionizing Radiation.

4.0 DEFINITIONS

Airborne Radioactivity: Radioactive material in any chemical or physical for that is dissolved, misted, suspended, or otherwise entrained in air.

Ambient Air: Air in the volume of interest, such as room atmosphere, as distinct from a specific stream or volume of air that may have different properties.

Annual Limit on Intake (ALI): The derived limit for the amount of radioactive material taken into the body of an adult worker by inhalation or ingestion in a year. ALI is the smaller value of intake of a given radionuclide in a year by the reference man that would result in a committed effective dose equivalent (CEDE) of 5 rems or a committed dose equivalent (CDE) of 50 rems to any organ or tissue.

Breathing Zone (BZ): A uniform description of the volume of air around the worker's upper body and head which may be drawn into the lungs during the course of breathing.

Committed Dose Equivalent (CDE): The dose equivalent to tissues or organs of reference that will be received from an intake of radioactive material by an individual during the 50-year period following the intake.

Committed Effective Dose Equivalent (CEDE): The sum of committed dose equivalents (CDEs) to various tissues in the body, each multiplied by the appropriate weighting factors found in 10 CFR 20.

Derived Air Concentration (DAC): The concentration of a given radioactive nuclide in air which, if breathed by the reference man for a working year of 2000 hours under conditions of light work (1.2 m^3 of air per hour), would result in an intake of one (1) ALI.

DAC-hour (DAC-hr): The product of the concentration of radioactive material in air (expressed as a fraction or multiple of the DAC for each radionuclide) and the time of exposure to that radionuclide in hours. A facility may take 2000 DAC-hr to represent 1 ALI.

Grab Sample: A single sample of ambient air collected over a short time.

Maximum Permissible Concentration (MPC): That concentration of radionuclides in air or water that will result in the Maximum Permissible Body Burden or Organ Burden and result in a whole body or organ receiving the annual dose limit if breathed in by a worker for 2000 hours.

Monitoring: The measurement of radiation levels, airborne radioactivity concentrations, radioactive contamination levels, quantities of radioactive material, or individual doses and the use of the results of these measurements to evaluate radiological hazards or potential and actual doses resulting from exposures to ionizing radiation.

MPC-hour (MPC-hr): The product of the concentration of radioactive material in air (expressed as a fraction or multiple of the MPC for each radionuclide) and the time of exposure to that radionuclide in hours.

Occupational Dose: An individual's ionizing radiation dose (external and internal) received as a result of that individual's work assignment.

Protection Factor: The degree of protection given by a respirator. The protection factor is used to estimate radioactive material concentrations inhaled by the wearer and is expressed as the ratio of ambient concentration of airborne radioactive materials to the concentration that can be maintained inside the respirator during use.

Representative: Sampling in such a manner that the sample closely approximates both the amount of activity and the physical and chemical properties of the material (e.g., particle size and solubility in the case of aerosol to which workers are exposed). Air sampling performed within the Breathing Zone (BZ) is considered representative of the airborne radioactive material concentration inhaled by the worker.

Restricted Area: An area to which access is limited to protect individuals against undue risks from exposure to radiation, radioactive materials, and chemical contaminants. All posted radiological or chemical areas are Restricted Areas.

5.0 RESPONSIBILITIES

5.1 Radiation Safety Officer (RSO)

- Manages the implementation of this procedure.
- Ensures technicians performing activities under this procedure are competent and have sufficient experience to perform assigned tasks.

5.2 Radiation Protection Technician (RPT)

- Initiates, collects, submits, counts, and documents air samples according to the requirements of this procedure, and the SSHP.
- Ensures he / she has sufficient experience and / or knowledge to perform assigned duties under this procedure.

6.0 PRECAUTIONS AND LIMITATIONS

- Running air samplers for extended periods may cause excessive dust loading of the filter media. The frequency of filter change-out should be increased if excessive dust loading is observed.
- Air samplers shall not be used in combustible / explosive atmospheres.
- Air sampling and sample counting equipment shall not be operated beyond their respective calibration periods.
- Air samples shall be taken in such a manner as to not contaminate the filter with materials that were not airborne during the sample interval or by re-suspension of loose contamination from surfaces near the sampling head.
- Sampler exhaust may cause the re-suspension of loose surface contamination if the sampler is positioned improperly.
- Consider higher volume air samplers when covering short duration tasks.
- The decision to provide individual monitoring devices to workers is influenced by the expected levels of intake, likely variations in dose among workers, and the complexity of measurement and interpretation of results.

7.0 ACTION STEPS

7.1 Air Monitoring Methods

1. Utilize the following monitoring methods to implement the radiological air monitoring program:
   - General Area (GA) Air Monitoring
   - Breathing Zone (BZ) Air Monitoring
   - Passive Radon Monitoring
   - Particulate Radon Grab Samples
   - Perimeter Monitoring, frequently referred to as Air Environmental (AE)
2. Air sampling equipment should be placed so as to:
   - Not directly contact a contaminated (transferable) surface.
   - Minimize interference with the performance of work.
   - Be easily accessible for changing filters and servicing.
   - Be downstream of potential release points.
   - Minimize the influence of supply airflow.
3. An airflow study of any indoor area to be monitored should be performed prior to placement of the sampler (other than BZ samplers). Additional studies should be performed after changes in the work area setup, ventilation systems, or seasons, if seasonal changes may affect airflow patterns.
4. Perform BZ air sampling in occupied areas where, under typical conditions, a worker is likely to be exposed to an air concentration of 10 % or more of the DAC.

7.2 General Area (GA) Air Sampling

1. GA samples are typically taken with low volume samplers such as LV-1 or equivalent. Specific instructions on the use and calibration of the LV-1 sampler are detailed in RP-110 *Operation of Low Volume Air Samplers*.
2. GA sampling shall be performed with instrumentation operating at volumes capable of meeting the Minimum Detectable Concentration (MDC) values established in the Technical Basis Document for Dosimetry and Air Sampling.
3. GA samples should be collected:
   - During work activities as a supplement to Breathing Zone (BZ) sampling as deemed appropriate.
   - At site boundaries to confirm effluent air discharge concentrations. These are the Air Environmental (AE) type samples.
   - At discharge points to determine the worst case airborne radiological conditions.
4. Document airflow studies, if performed in the appropriate project logbook or as directed by the RSO.

5. Select a calibrated low / high volume sampler with the appropriate glass fiber air filter and place the sample head into position. The fuzzy side of the filter should face outwards.
6. Turn the sampler ON. At a minimum, document the following information on the air filter envelope or log sheet:
    - Sampling station identifier (as determined by the RSO)
    - Sampler model
    - Serial number
    - Date / time on
    - Flow rate
    - On by (individual starting sampler)
7. When air monitoring is complete, observe the sampler flow rate and turn the sampler off. At a minimum, document the following information on the air filter envelope or logsheet:
    - Date / time off
    - Flow rate
    - Off by (individual terminating sample)
8. Remove and / or replace the sample head and filter using caution to prevent cross-contamination.
9. Store the filter in a protective container to minimize the loss of collected material.
10. Submit sample to counting lab for analysis.

7.3 Breathing Zone (BZ)

1. Specific instructions on the use and calibration of Lapel Samplers are detailed in RP-110 *Operation of Low Volume Air Samplers*.
2. Collect BZ samples during entries into posted airborne radioactivity areas and during activities which have a reasonable potential of producing airborne radioactivity (e.g., excavating contaminated soils, surface destructive activities on surfaces with fixed contamination) as determined by the RSO.
3. Position the sampler on the individual representative of the worst-case exposure for the group if a single lapel sampler is used for multiple members of a work group. Base this selection on operating experience and consultation with the RSO. A single lapel sampler should be used for a group of no more than four workers spending greater than one hour in the work area under the same RWP.
4. Ensure the sample head is positioned as close to the breathing zone as practical without interfering with the work or the worker.
5. Operate lapel samplers according to the appropriate instrument use procedure. At a minimum, document the following information on the air filter envelope or log sheet:
    - Wearer's name(s)
    - Applicable Hazardous Work Permit (HWP) number

- Sampler model / serial numbers
- Date / time On
- Flow rate (sampler must be running)
- On by (individual starting sampler)

6. Upon exit from the work area, note the flow rate, turn the sampler OFF and detach from the worker / object. Note that sampling may be suspended / restarted during the workday to facilitate break periods. Accurate volume tracking is crucial during these periods of non-operation.
7. Perform necessary post-operation sampler checks according to the specific instrument use procedure.
8. Carefully, remove the air filter from the sample head and place in air filter envelope. Complete the pre-printed air filter envelope or sample log sheet:
   - Date / time off
   - Flow rate
   - Off by (individual stopping sampler)
9. Submit sample to Counting Room for analysis.

7.4 Radon and Thoron Progeny

1. High volume or low volume grab samplers such as HV-1, LV-1, or RAS-1 (typically in the 35-75 lpm range) should be used for collecting radon and thoron samples.
2. Radon and thoron samples should be collected:
   - During work activities as deemed appropriate by the RSO or designee.
   - At restricted area boundaries as deemed appropriate by the RSO or designee.
   - Each frequently occupied work location should have its own samplers.
   - Airflow patterns should be considered in placing samplers so that the sampler is likely to be in the airflow downstream of the source.
   - A simultaneous background sample shall be taken upwind of all activities when radon and thoron sampling is performed. This sample is critically important.
   - When collecting a radon and thoron breathing zone sample, the sampler should be located in the breathing zone for the worker. Preferably it should be held immediately downwind of the worker and moved around with the worker.
3. Select a calibrated high volume sampler with a 47 mm filter and place the sample head into position. The preferred filter is a membrane filter such as the F&J Specialty Products, Inc. model number A020A047A or equivalent. Alternatively, a glass fiber filter such as the F&J Specialty Products, Inc. model number AE-47 or equivalent can be used

4. Turn the sampler ON and complete the required information on the air filter envelope to include:
   - RWP number, if appropriate
   - Sampler model and serial number
   - On date, time, and flow rate
   - On by (site worker initials)
   - Sample location
5. Collect a sample for exactly 5 minutes, with no more than a 5-second uncertainty. Exercise caution when handling sample head so as not to cross-contaminate the air filter.
6. Remove air filter from sample head and place in air filter envelope. Complete the required information on the air filter envelope including:
   - Off date, time, and flow rate
   - Site worker stopping the sampler
7. Submit the sample to the counting room within 30 minutes after collection. Samples must be counted between 40 and 90 minutes, or they will be void.
8. Analyze the sample in accordance with Sections 8.1 or 8.2, whichever is appropriate.
9. Alternate industry-accepted methods for Radon-Thoron monitoring may be used at the discretion of the RSO with concurrence from the Project Certified Health Physicist.

7.5 Perimeter Environmental Air (AE) Sampling

1. Perimeter samples are taken with low volume samplers such as LV-1 or equivalent. Specific instructions on the use and calibration of the LV-1 sampler are detailed in RP-110 *Operation of Low Volume Air Samplers*.
2. Perimeter samples are collected to verify compliance with off-site release criteria.
3. Samples are collected at locations designated by the RSO. The air sampling locations should be established at the most likely downwind perimeter boundary, as determined by evaluation of local meteorological data, and / or the nearest perimeter boundary from active work areas.
4. Perimeter samplers should be operated 24 hours a day 7 days a week if possible.
5. Filters from continuously operating perimeter air samplers are normally changed out weekly. Filter change-out of perimeter air samplers will be performed at a frequency long enough to ensure acceptable counting statistics and short enough to maintain consistent sampler flow rates.
6. Perimeter sampler operation shall be verified on a daily basis around locations when airborne generating activities are in progress. This requirement may be relaxed by the RSO for samplers with data logging capability.

7. Document daily verification (i.e., flow rate) and notify the RSO of any discrepancies. Replace filter and investigate pump operation if daily flow rates vary by greater than 20%.
8. Any sampler that is out of service due to malfunction for more than 1 hour and any invalid samples should be brought to the attention of the RSO.
9. Samples are to be collected in accordance with Section 7.2, Steps 5-10.

7.6 Passive Radon Monitoring

1. Passive radon monitoring methods include the use of either alpha track-etch detectors or electrets.
2. Detectors should be placed for a length of time, so that the minimum detectable concentration is 0.1 pCi/l or less, following manufacturer guidelines. The length of placement is generally 1 month or greater. Locations selected should be representative of the breathing zone, when practical. A simultaneous background sample should always be taken at a location unaffected by site activities. This sample is critically important.
3. Open the bag containing the detector and place the detector in a protective container to allow for air circulation. Follow manufacturer guidelines to activate the detector, as necessary.
4. Record in the logbook:
   - Sample location
   - Date and time of placement
   - Serial number of the detector
   - Initials of the worker placing the detectors
5. Ship the detector to the manufacturers processing center to read the results.

8.0 ANALYSIS OF AIR SAMPLES

General Area (GA), Breathing Zone (BZ), and Perimeter Air (PA) samples should be submitted to a counting room or off-site laboratory for gross alpha/beta analysis. Samples may be sent to an outside laboratory for isotopic analysis as necessary per the RSO.

8.1 Analysis for Radon and Thoron Progeny from a 5-Minute Low Volume Grab Sample

8.1.1 Count the sample twice for alpha activity using a Ludlum 2929, Ludlum 2000, or Equivalent. The first count should start at least 40 minutes after the end of the sample, but not greater than 90 minutes at the end of sample collection. The second count should start at least 5 hours after the end of the count, but not greater than 17 hours after the end of the first count. Count the sample for 5 minutes each time.

NOTE: It is not recommended that a gas flow proportional counter be used for this analysis as there is a reasonably high probability of contaminating the instrument with radon and / or thoron progeny.

8.1.2 Calculate the thoron progeny (TDC) in working levels from the delayed (second) count as follows:

$$TDC = \frac{cpm_{net}}{E \cdot V \cdot CE \cdot SAF \cdot F_{Th}}$$

where,

cpm_{net} = (gross counts/count time) - background cpm of counting instrument

V = Volume of air in liters

E = efficiency of counting instrument

CE = Filter collection efficiency (normally 0.998)

SAF = Self absorption factor (normally 0.7 for glass fiber filters and 1.0 for membrane filters)

F_{Th} = Working level factor from Graph 1 (Attachment 1).

8.1.3 Calculate the radon progeny (RDC) in working levels from the first count as follows:

$$RDC = \frac{\left(\frac{cpm_{net}}{E \cdot V \cdot CE \cdot SAF} - TDC\ x16.5 \right)}{F_{Rn}}$$

where,

cpm_{net} = (gross counts/count time) - background cpm of counting instrument

V = Volume of air in liters

E = efficiency of counting instrument

CE = Filter collection efficiency (normally 0.998)

SAF = Self absorption factor (normally 0.7 for glass fiber filters and 1.0 for membrane filters)

F_{Rn} = Radon working level factor from Graph 2 (Attachment 2).

TDC = Thoron Progeny determined from second count.

8.2 Alternate Method for the Analysis of Radon Progeny from a 5-Minute Low Volume Grab Sample

This section only applies to the determination of radon and not the determination of thoron.

8.2.1 Count the sample once for alpha activity using a Ludlum 2929, Ludlum 2000, or Equivalent. The count should start at least 40 minutes after the end of the sample, but not greater than 90 minutes at the end of the count. Count the sample for 5 minutes.

NOTE: It is not recommended to use a gas flow proportional counter for this analysis as there is a reasonably high probability of contaminating the instrument with radon and / or thoron progeny.

8.2.2 Calculate the radon progeny (RDC) in working levels from the first count as follows:

$$RDC = \frac{cpm_{net}}{E \cdot V \cdot CE \cdot SAF \cdot F_{Rn}}$$

where,

cpm_{net} = (gross counts/count time) - background cpm of counting instrument

V = Volume of air in liters

E = efficiency of counting instrument

CE = Filter collection efficiency (normally 0.998)

SAF = Self absorption factor (normally 0.7 for glass fiber filters and 1.0 for membrane filters)

F_{Rn} = Radon working level factor from Graph 2 (Attachment 2).

9.0 REPORTS

Maintain air monitoring instrument data, sampling data, and analysis results as a quality record.

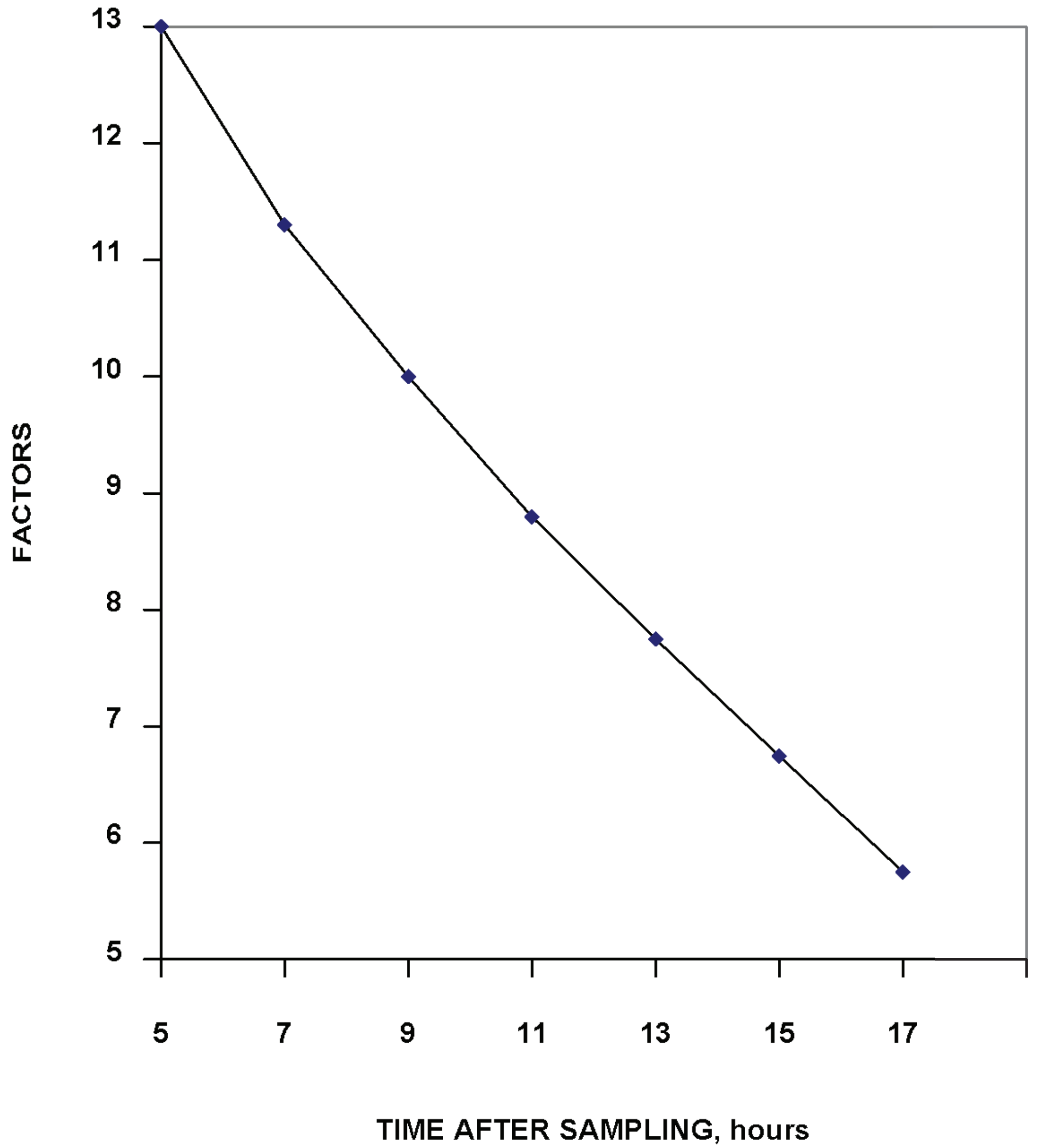
10.0 ATTACHMENTS

Attachment 1 Graph 1, Thoron Working Level Factors

Attachment 2 Graph 2, Radon Working Level Factors

ATTACHMENT 1

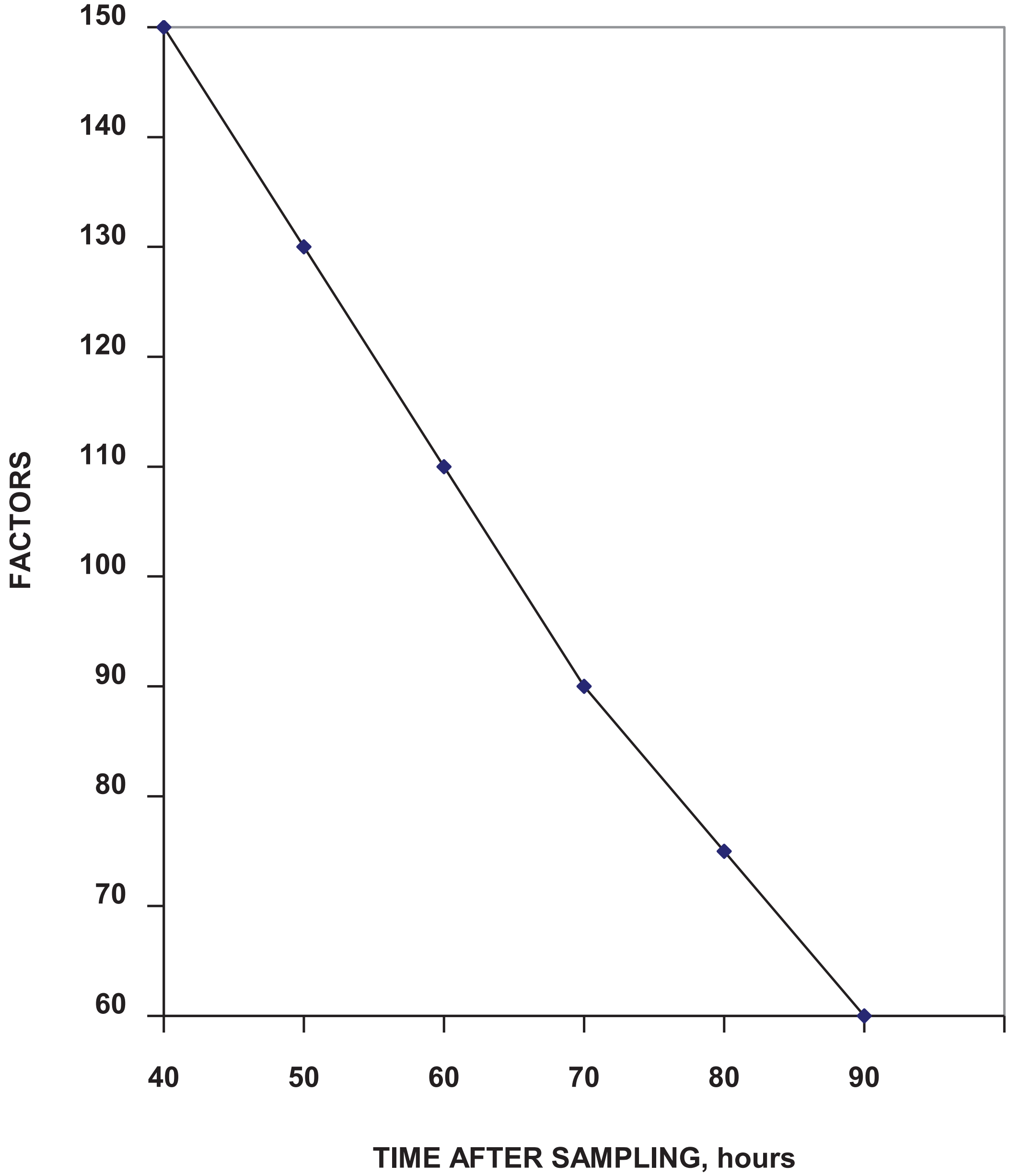
GRAPH 1, THORON WORKING LEVEL FACTORS



Time factors versus time after sampling for thoron daughter samples.

ATTACHMENT 2

GRAPH 2, RADON WORKING LEVEL FACTORS



Time factors versus time after sampling for radon daughter samples.

APPROVED:

5/31/14
Technical Services Manager Date

5/31/14
Corporate Certified Health Physicist Date

1.0 PURPOSE

This procedure specifies the methods for set-up, daily pre-operational check, and operation of portable count-rate survey instruments. These instruments are used for the detection of radioactivity on personnel, on or within material surfaces, and in the environment. This procedure does not include associated instrument calibrations or cover the operation of exposure rate instruments.

2.0 APPLICABILITY

This procedure specifically addresses those meter-probe combinations that report values in units of counts or counts per minute (cpm) such as Ludlum Measurements models 2221 and 2241 Scaler-Ratemeters; and the Ludlum Model 177 Alarming Ratemeter or equivalent. These meters are mated to probes including the Ludlum Model 44-10, 44-20, and 44-62 NaI Detectors, the Ludlum Model 43-5 Alpha Scintillation Detector, and the Ludlum Model 44-9 Pancake Geiger-Mueller detectors or equivalent. Additional equivalent meters and probes may be used under this procedure without revision as approved by the RSO.

3.0 REFERENCES

1. ANSI N323A-1997, Radiation Protection Instrumentation Test and Calibration, Portable Survey Instruments.
2. Instrument Technical Manuals.
3. Perma-Fix Environmental Services (PESI) Radiation Protection Plan (RPP)
4. RP-104, Radiological Surveys

4.0 DEFINITIONS

cpm: counts per minute

DFSCL: Daily Field Source Check Logsheet.

dpm: disintegrations per minute

HV: High Voltage

MDA: Minimum Detectable Activity

5.0 RESPONSIBILITIES

5.1 Radiation Safety Officer (RSO)

- Reviewing and approving changes to this procedure and ensuring compliance with applicable regulations.
- Ensuring an adequate inventory of Radiation Protection instruments are available to support remediation activities.
- Overseeing the issue, control, and accountability of Radiation Protection instrumentation per the requirements of this procedure.
- Ensuring transmittal of all issue, control and accountability records to the appropriate document control authority when applicable.

5.2 Radiation Protection Technician (RPT)

- Maintaining instrument documentation and records as required by this procedure.
- Maintaining adequate instrument and equipment availability.
- Verifying current calibration and response test dates prior to issue or use of instruments.
- Promptly returning instruments to their proper location when work is complete.
- Ensuring that instruments are properly surveyed for contamination and decontaminated as necessary after use.

6.0 PREREQUISITES

- Only personnel with appropriate documented training shall issue or use RP instrumentation.
- Instruments and detectors shall be inspected for mechanical damage, and response tested prior to issue.
- Any instrument to be used shall have a current calibration label affixed to the instrument.

7.0 PRECAUTIONS AND LIMITATIONS

- Portable count rate survey instrumentations are susceptible to damage from physical and environmental stresses.
- QA/QC requirements established by an approved survey plan (e.g., Master Final Status Survey Plan) supercede the requirements of this procedure.

8.0 APPARATUS

- Appropriate survey instruments

9.0 RECORDS

- Portable Instrument Set-Up Sheet
- Daily Field Source Check Logsheet

10.0 PROCEDURE

10.1 General

1. Ensure the meter-probe combination selected is within their acceptable calibration periods. The swapping of probes between meters is permitted, but not encouraged. The following precautions and limitations must be observed and the following action steps must be taken:
   - If the meter-probe combination is calibrated as a set, Probe swapping is not permitted, without specific RSO approval.
   - The HIGH VOLTAGE (HV) and THRESHOLD settings for the meter-probe combination shall be identical. Note that the Ludlum 177 and 2241 do not have user adjustable settings for HV and THRESHOLD.
   - An initial set-up must be performed for each meter-probe combination prior to field use.
   - A source with known pedigree must be counted to verify the efficiency is within 10% of the calibrated efficiency, as applicable.
2. The RP Group will coordinate the calibration of boxes and probes on a minimum annual basis and after major repair operations. Battery and / or cable change-outs do not require re-calibration. Calibration procedures are outside of the scope of this instruction.
3. Pre-operational checks are required daily prior to use. Post-operational checks are performed as specified in work plans or procedures. Instruments used in the performance of daily activities do not normally require a post-operational check..
4. Instruments that fail operational checks or malfunction during use should be tagged or labeled "Out-of-Service" or "Do Not Use" and segregated from operational instruments. If possible, describe the problem on the tag / label and add initials and date.
5. Instruments leaving RP Group control (i.e., repair, calibration, excess, etc.) shall be surveyed for unconditional release according to the contamination criteria established in Table 1 of the Site RPP. The repair / calibration center may request a copy of the survey accompany any shipments of RP instruments.
6. Ensure meters with a "WINDOW" or "WIN" setting are set to "OUT."
7. Instruments may be operated in the FAST response mode if necessary. This setting is recommended if the audible response cannot be heard. SLOW response shall be used when performing instrument set-up and operational checks.
8. Ludlum NaI crystals are located in the end of the probe opposite of the cable connection. Use this end for surveys.
9. Calibration stickers are attached to the instruments and detectors. Illegible stickers should be replaced prior to instrument use.
10. Instrument set-up and subsequent operational checks should be performed in the same location, with consistent temperature and background radiation levels.

11. Source positioning devices (i.e., jigs) may be used to ensure a reproducible geometry between instrument checks. Source geometry must be consistent between initial instrument set-up and subsequent operational checks.
12. Instruments that do not have scaler capability should be set-up and checked by replacing 1-minute timed counts with static count rate measurements. Each static measurement should last until the meter reading fully stabilizes.

10.2 Instrument Set-Up

1. Inspect the meter-probe combination for physical damage or defect.
2. Complete Section A of the Portable Instrument Set-Up Sheet (Attachment 1).
3. Perform 10 1-minute source counts alternating with 10 1-minute background counts. Remove / replace the source and reposition the probe after each count. During alternating background counts, ensure that the source is sufficiently shielded so as not to impact background values.

   NOTE: Counts (Source and Background) performed with a Ludlum 43-5, or other large surface area probe, should be alternated between the Heel, Center, and Toe Positions, if the source surface is smaller than the active surface area of the probe. Instrument response can vary greatly across the probe surface.
4. Document each count on the Portable Instrument Set-Up Sheet.
5. Calculate and record the net count value by subtracting the corresponding background count from each source count.

   NOTE: Determining Sigma (Standard Deviation) values is useful when specific plans or activities require higher data quality objectives and / or when the development of control charts is necessary.
6. Calculate and record the following values from the obtained background counts:
   - Avg. Value (Sum of values / # of counts)
   - Sigma Value (Standard Deviation of all counts)
   - 20% Value (Avg. Value * 0.20)
7. Calculate and record the +/- 20% Values and the +/- 1,2, and 3 Sigma values using the AVG. VALUE as a reference point.
8. Repeat the previous two steps for determining NET COUNT acceptable ranges. The 3 Sigma value must be less than the +/- 20% value.
9. Obtain a blank Daily Field Source Check Logsheet (DFSCL) (Attachment 2) and transfer the instrument, source, and acceptable range data, as applicable, from the Portable Instrument Set-Up Sheet.
10. Place the DFSCL in the designated use location and forward the completed Portable Instrument Set-Up Sheet and submit to the RSO, or designee for review.
11. Ensure sources are stored properly after use in the designated source storage location.

10.3 Operational Check

1. Obtain the selected meter-probe combination and corresponding DFSCL (Attachment 2).
2. Record the date and time on the DFSCL.
3. Perform and document the following checks on the DFSCL, as applicable:
    - Perform a physical inspection. Observe for instrument damage. Alpha probes should be checked for light leaks by inverting the probe face towards a light source and observing instrument response. If the instrument fails to respond at all or over-responds this may be an indication of a light leak and should be investigated further, prior to proceeding.
    - Perform a battery check. Instrument Models differ in method. Some meters have a visible battery range on the meter face. The Ludlum Model 2241 has a battery indicator in the digital display that lights if the batteries require replacement. The Ludlum Model 2221 has a BAT button that brings up the battery level in the digital display. Ensure this value is at least 5.0v. Change batteries and retest as necessary.
    - Verify and adjust the HV, when possible, to match the initial set-up data. Minute differences in HV (+/- 5v) are acceptable without adjustment.
    - Perform an audio response check..
4. Perform and record a 1-minute background count. Report any abnormal background responses to the RSO, prior to instrument use. Normally acceptable background levels < 5 cpm for alpha probes, and < 300 cpm for Pancake G-M probes. Acceptable background levels for NaI probes are variable due to crystal size and based on technician experience.
5. Perform and record a 1-minute source gross count using the same source and geometry applied during initial set-up.
6. Calculate and record the net count value.
7. Compare the net count value to the acceptable range. If the instrument response is outside the acceptable range, the process may be repeated a maximum of 1 additional time before placing the instrument out-of-service.
8. If the instrument fails the pre-operational checks, mark FAIL, initial the DFSCL, and place the instrument out-of-service. Deliver completed DFSCL to the RSO or designee, and explain the failed condition(s).
9. If all checks pass, mark PASS, initial the DFSCL, and return form to designated in-use storage location. This may be a binder, folder, or cabinet. The instrument is now ready for use.
10. If the instrument will be used for routine personnel exit monitoring ensure the alarm threshold is set to alarm and actuates at a level below the site removable contamination limits identified in Table 6-1 of the Site Safety & Health Plan (SSHP). Make adjustments as necessary.

11. Ensure sources are stored properly after use in the designated source storage location.

10.4 Operations

1. Operate instrument in a manner that minimizes the potential for cross-contamination and physical damage.
2. Evaluate the surface or area to be surveyed for potential scanning interferences. For example, thin layers of water or soil can prevent the detection of alpha contamination. Another example is the use of a NaI probe to qualify soil contamination. The presence of standing water can have a significant impact on instrument response. Initiate necessary corrective actions prior to survey or note conditions during survey reporting.
3. Most instruments will operate in temperatures between 10 and 120 degrees Fahrenheit. However, anytime the temperature is outside of the 32 degree (freezing) or 100 degrees ranges, observe the following precautions:
    - Use particular caution with NaI crystals that may shatter under extreme temperature changes. If the temperature difference is greater than 30 degrees between storage and usage locations, wrap the probe tightly in a cloth towel or other insulator and allow warming or cooling over at least one hour prior to use.
    - Periodically check the instrument against a known source of radiation or contamination. If the instrument appears to be responding incorrectly contact the RSO or designee for guidance.
    - Contact the RSO for guidance anytime work is planned outside of the 10 to 120 degree range.
4. Protect instruments to the extent possible from exposure to moisture (i.e., rain, snow, etc.) during use. Instruments shall be stored in a safe manner when not in use.
5. Minimum Detectable Activities (MDA) for each survey should be determined by evaluating field background levels, not background values obtained during operational checks. Calculate MDA using the formula provided in PP-8-805, "Radiological Surveys."
6. Determining activity in disintegrations per minute (dpm) should be performed using the instrument efficiency obtained during calibration. Efficiencies are normally not established for NaI probes, and therefore should not be used for quantifying activity concentrations. The use of NaI probes for activity quantification shall be evaluated by the RSO prior to performance.
7. Observe the following when performing survey scans and static measurements:
    - Alpha probes should be held within ¼-inch of the surface being surveyed. Probe speed should not exceed 1 probe width per second.
    - Beta probes should be held within ½-inch of the surface being surveyed. Survey speed should not exceed one probe width per second.

- NaI probes should be held as close as possible to the surface being surveyed without contaminating the probe housing. Note that the crystal is located in the probe end opposite the cable connection. Use appropriate sleeving or wrapping in wet or dirty environments.
- The scan speed for performing Gamma Walkover Surveys is approximately 0.5 m/sec. Move the detector side to side using a 1-meter path length. Each side-side swing should take 2 seconds to traverse the 1-meter path. Advance the probe forward as you go at a rate of approximately 0.5 m/sec. Use the audio function. When increased counts are detected, slow down and locate the source as would be done in a normal survey. Walk parallel paths to ensure that 100% of the area is surveyed. Ensure that the survey extends to the boundaries of the survey unit. Pay particular attention to low lying areas, ditches, and points of possible contamination.
- Static measurements should be performed in any location were scans indicated the presence of activity. This is due to the fact that instrument MDAs are normally based on a 1-minute static measurement.
- All static measurements should be at least 1 minute, if the instrument has a scaler function. If the instrument is a ratemeter only, static measurements should last until the meter reading has fully stabilized.

8. Perform a post-operational check after use if directed by work plan, procedure, or the RSO.

11.0 ATTACHMENTS

Note: Attachments may be revised without formal review of this procedure and are attached as examples only. Please contact the RSO for a current copy of these attachments.

Attachment 1 Portable Instrument Set-Up Sheet (Typical)

Attachment 2 Daily Field Source Check Logsheet (Typical)

Attachment 1
Portable Instrument Set-Up Sheet (Typical)

PORTABLE INSTRUMENT SET-UP SHEET

Set-Up Location: ______________________

INSTRUMENT DATA			COUNT (n)	Source Counts	Source Count Time (min)	Source CPM	Background Counts	Background Count Time (min)	Background CPM	NET CPM
	INSTRUMENT	DETECTOR	1							
MODEL										
SERIAL #			2							
CAL DUE										
HV			3							
THRESHOLD										
SOURCE DATA			4							
ISOTOPE			5							
SERIAL #			6							
			7							
ACTIVITY (uCi)			8							
ACTIVITY (dpm)			9							
			10							

REMARKS

CALCULATED VALUES		
Background (CPM)		Net CPM
	Average	
	+/- Sigma	
	+/- 20 %	

ACCEPTABLE RANGES		
Background (CPM)		Net CPM
	+ 20 %	
	+ 3 Sigma	
	+ 2 Sigma	
	+ 1 Sigma	
	- 1 Sigma	
	- 2 Sigma	
	- 3 Sigma	
	- 20 %	

Performed By:	Date / Time:	Reviewed By:	Date / Time:

Attachment 2
Daily Field Source Check Logsheet (Typical)

DAILY FIELD SOURCE CHECK LOG

MONTH / YEAR: ______________________

INSTRUMENT DATA

	INSTRUMENT	DETECTOR
MODEL		
SERIAL #		
CAL DUE		

SOURCE DATA

ISOTOPE	
SERIAL #	
ACTIVITY dpm	

INSTRUMENT RANGES

	Background	Net CPM
+ 20 %		
+ 3 Sigma		
+ 2 Sigma		
+ 1 Sigma		
- 1 Sigma		
- 2 Sigma		
- 3 Sigma		
- 20 %		

NET CPM CALCULATION
{B} - {A} = {C}

Date/Time	Physical	Battery	High Voltage	Audio	Background CPM {A}	Source CPM {B}	Net CPM {C}	PASS or FAIL	Tech. Initials

Remarks:

Reviewed by:

PERMA-FIX ENVIRONMENTAL SERVICES			
TITLE:	**Dose Rate Instruments**	**NO.:**	RP-109
		PAGE:	1 of 6
		DATE:	May 2014

APPROVED:

_____________________________ 5/31/14
Technical Services Manager Date

_____________________________ 5/31/14
Corporate Certified Health Physicist Date

1.0 PURPOSE

This procedure specifies the methods for performing source checks and operating portable Gamma scintillation dose rate instruments, specifically, the Ludlum Model 12s uR and the Bicron Model Micro Rem. These instruments are used for the evaluation of exposure rates from radioactive materials and determining environmental radiation levels.

2.0 APPLICABILITY

This procedure addresses those instruments that measure dose rate from a scintillation detector and have displays that read in uR/hr, uRem/hr and/or mRem/hr such as Ludlum 12s, Bicron Micro Rem, or Eberline RO-2. Equivalent instruments that operate in a similar fashion to those identified in this section may be operated under this Project Procedure with RSO approval.

3.0 REFERENCES

1. ANSI N323-1978, Radiation Protection Instrument Test and Calibration.
2. Instrument Technical Manuals.
3. Perma-Fix Environmental Services (PESI) RPP

4.0 DEFINITIONS

None

5.0 RESPONSIBILITIES

5.1 Radiation Safety Officer (RSO)

- Reviewing and approving changes to this procedure and ensuring compliance with applicable regulations.
- Ensuring an adequate inventory of Radiation Protection instruments are available to support remediation activities.
- Overseeing the issue, control and accountability of Radiation Protection instrumentation per the requirements of this procedure.

- Ensuring transmittal of all issue, control and accountability records to the appropriate document control authority when applicable.

5.2 Radiation Protection Technician (RPT)

- Maintaining instrument documentation and records as required by this procedure.
- Maintaining adequate instrument and equipment availability.
- Verifying current calibration and response test dates prior to issue or use of instruments.
- Promptly returning instruments to their proper location when work is complete.
- Ensuring that instruments are properly surveyed for contamination and decontaminated as necessary, after use.

6.0 PREREQUISITES

- Only personnel with documented training shall issue or use RP instrumentation.
- Instruments and detectors shall be inspected for mechanical damage, and response tested prior to issue.
- Any instrument to be used shall have a current calibration label affixed to the instrument.

7.0 PRECAUTIONS AND LIMITATIONS

- Portable count rate survey instrumentations are susceptible to damage from physical and environmental stresses.

8.0 APPARATUS

- Survey instrument
- Tech source
- Source positioning device (jig)

9.0 RECORDS

- Daily Field Source Check Log – Exposure Rate Instruments (Attachment 1)
- Exposure Rate Instrument Set-Up Sheet (Attachment 2)

10.0 PROCEDURE

10.1 General

1. Ensure the instrument selected is within their acceptable calibration periods. This is indicated on an attached calibration sticker. Illegible stickers should be replace prior to instrument use.
2. The RP Group will coordinate instrument calibration on a minimum annual basis and after major repair operations. Battery change-outs do not require re-calibration. Calibration procedures are outside of the scope of this instruction.
3. Pre-operational source checks are required daily, or prior to each intermittent use, whichever is less frequent. Post-operational source checks are performed as specified in work plans or procedures. Instruments used in the performance of daily activities do not normally require a post-operational source check.

4. Instrument set-up and subsequent operational checks should be performed in the same location, with consistent temperature and radiation background levels.
5. Use a gamma check source with an activity sufficient to produce contact exposure rates at least ten times higher than background. Cs-137 is typically since it emits 662 keV gamma rays which are representative of the mid-range of gamma energies encountered at NFSS. Alternate sources may be used with RSO approval.
6. Source positioning devices (i.e., jigs) should be used to ensure a reproducible geometry between instrument checks. Source geometry must be consistent between initial instrument set-up and subsequent operational checks.
7. The Ludlum 12s may be operated in the FAST response mode. Switch to SLOW response for obtaining precise readings.
8. Internal scintillation crystals are orientated towards the front of the instrument. Meter cases have visible indicators showing optimum locations to obtain measurements (i.e. effective detector center).
9. Allow instrument readings to maximize prior to recording instrument reading. This may take up to twenty seconds. Note that the needle may not rest on a single value, but may fluctuate slightly between two points on the scale. If this is the case, an average reading should be obtained by summing these two end points and dividing by two.
10. Instruments should be allowed to warm-up for at least one minute prior to obtaining readings.
11. Report any abnormal instrument readings (e.g., unstable analog meter fluctuations), or background inconsistencies to the RSO, prior to continuing instrument use.
12. Instruments that fail operational checks or malfunction during use should be tagged or labeled “Out-of-Service,” or “Do Not Use,” and segregated from operational instruments. If possible, describe the problem on the tag / label and add initials and date.
13. Instruments leaving RPP Group control (i.e., repair, calibration, excess, etc.) shall be surveyed for unconditional release. The repair / calibration center may request a copy of the survey to accompany shipments of RP instruments.

10.2 Instrument Source Check

1. Obtain the selected instrument.
2. Obtain the corresponding Daily Field Source Check Log – Exposure Rate Instruments form, Attachment 1. This form will be referred to as the “Source Check Log.” Initiate a new Source Check Log, if necessary.
3. Perform a physical inspection of the instrument. Place particular emphasis on the following items:
    - Instrument case is not visibly damaged beyond minor scrapes and scratches.
    - Analog display is not cracked or otherwise damaged.

- Switches and buttons are functional.
- Audio, if present, is functional.
- Calibration labels are legible and instrument is within calibration period.

4. Note results of physical inspection on the Source Check Log.
5. Verify the battery level is within the acceptable range on the analog display. Replace batteries and re-verify, as necessary.
6. Note battery check results on the Source Check Log.
7. Verify the high voltage (HV) level is within the acceptable range on the analog display, if present. Place the instrument out-of-service if the HV is outside the acceptable range.
8. Note the HV check results on the Source Check Log.
9. If acceptable background ranges have not been established, perform the following:
    - Obtain a blank NFSS Exposure Rate Instrument Set-Up Sheet, Attachment 2. This form will be referred to as the "Set-Up Sheet."
    - Record the basic source and instrument information at the top of the form.
    - Using the instrument and the source jig (without source), obtain and record ten background readings. The instrument should be removed from the source jig and repositioned after each reading is obtained. Make sure the location where readings are obtained has stable background levels and is the location used for subsequent source checks.
    - Calculate and record the average background value and +/- 20% values on both the set-up and source check logsheets.
10. Obtain and record an average background reading on the source check log.
11. Compare the average background reading to the acceptable range. If background response is outside this range, report the condition to the RSO for evaluation, otherwise continue with source check process.
12. Obtain the source to be used for instrument source checks.
13. If acceptable source check ranges have not been established, perform the following:
    - Obtain the Set-Up Sheet used to determine acceptable background ranges for the instrument.
    - Using the instrument and the source jig (with source), obtain and record ten contact source readings. The instrument and source should be removed from the source jig and repositioned after each reading is obtained. Make sure the location where readings are obtained is the same location where previous background readings were obtained.
    - Calculate and record the average source value and +/- 20% values on both the set-up and source check logsheets.

14. Load the source and instrument onto the source jig.
15. Obtain and record the "CONTACT" reading.
16. Verify the contact reading is within the acceptable range (+/- 20%).
17. If the contact source reading falls outside the acceptable range, tag the instrument out of service and notify the RSO, otherwise continue.
18. Complete the source check log including technician initials. The instrument is now ready for use.
19. Ensure sources and forms are stored properly after use in the designated storage location. Forms are retained in RP Instrument logbooks of field files during instrument use (i.e. calibration) cycle. Records are then reviewed by the RSO, or designee for completeness and forward to Project Records for retention.

10.3 Operations

1. Verify that required source checks have been performed prior to initial instrument use.
2. Operate instrument in a manner that minimizes the potential for cross-contamination and physical damage.
3. Limit readings taken while the instrument is positioned sideways to minimize the effects of "geotropism" on the analog needle.
4. Obtain readings by positioning the instrument as close to the detector's "effective center" as possible. The detector effective center is represented on the instrument housing a cross inside a circle on the Bicron Micro Rem, and a small circular depression on the Ludlum 12s. Overall optimum readings are collected from the front of the instrument housing.
5. Most instruments will operate in temperatures between 10 and 120 degrees Fahrenheit. However, anytime the temperature is outside of the 32 degree (freezing) or 100 degree ranges, observe the following precautions:
    - Be observant of instrument response to background. If the instrument begins to show a decreased response to expected background levels contact the RSO, or designee for guidance.
    - If practicable, perform a period response check of the instrument against a known source of radiation. If the instrument appears to be responding incorrectly contact the RSO or designee for guidance.
    - Contact the RSO for guidance anytime work is planned outside of the 10 to 120 degree range.
6. Protect instruments, to the extent possible, from exposure to moisture (i.e. rain, snow, etc.) during use. Instruments shall be stored in a safe manner when not in use.
7. Perform a post-operational source check after use, if directed by work plan, procedure, or the RSO.

11.0 ATTACHMENTS

Attached forms are examples and may be modified by the RSO, as needed, without revision to this procedure.

Attachment 1 Daily Field Source Check Log – Exposure Rate Instruments (Typical)

Attachment 2 Exposure Rate Instrument Set-Up Sheet (Typical)

Attachment 1
Daily Field Source Check Log – Exposure Rate Instruments (Typical)

FMSS DAILY FIELD SOURCE CHECK LOG
- EXPOSURE RATE INSTRUMENTS

MONTH / YEAR: ____________________

INSTRUMENT DATA	
	INSTRUMENT
MODEL	
SERIAL#	
CAL DUE	
HV	

SOURCE DATA	
ISOTOPE	
SERIAL #	
ACTIVITY uCi	

INSTRUMENT RANGES		
	Background	Contact Source
+ 20 %		
- 20 %		

Units (Circle One

uR urem mR mrem R rem

Date/Time	Physical	Battery	High Voltage	Audio	Background	Contact Source	PASS or FAIL	Tech. Initials

Remarks:	**Reviewed by:**

Attachment 2
Exposure Rate Instrument Set-Up Sheet (Typical)

FMSS EXPOSURE RATE INSTRUMENT SET-UP SHEET

Set-Up Location: ______________________

INSTRUMENT DATA		READING (n)	Background Rate	Contact Source Rate	CALCULATED AVERAGE AND RANGES		
	INSTRUMENT	1			Background		Contact Source
MODEL		2				Average + 20%	
SERIAL #		3				Average	
CAL DUE DATE		4					
HV		5				Average - 20%	
SOURCE DATA		6			Units (Circle One)		
ISOTOPE		7			uR urem mR mrem R rem		
SERIAL #		8			REMARKS		
		9					
ACTIVITY (uCi)		10					

Performed By:	Date/Time:	Reviewed By:	Date/Time:

PERMA-FIX ENVIRONMENTAL SERVICES

TITLE: Radioactive Materials Control and Waste Management Program	NO.: RP-111
	PAGE: 1 of 6
	DATE: March 2017

APPROVED:

Technical Services Manager — Date: 03/03/17

Corporate Certified Health Physicist — Date: 03/03/17

1.0 PURPOSE

This procedure provides guidance and requirements for the control of radioactive materials including the management of radioactive waste. The Radioactive Materials Control and Waste Management Program applies to the receipt, inventory, storage and handling of radioactive materials; the release of materials from Restricted Areas; the control of radioactive sealed sources; the control of materials and contaminated tools and equipment entering and/or leaving Restricted Areas; and the management of waste including transportation and disposal.

2.0 APPLICABILITY

This procedure applies to all PESI Project personnel and all decommissioning projects that involve radioactive materials. This procedure does not apply to the monitoring of liquid and gaseous effluents, radiological environmental monitoring, or final termination surveys of the reactor or facilities.

3.0 REFERENCES

1. Title 17, California Code of Regulations, Division 1, Chapter 5, Subchapter 4 “Radiation.”
2. Title 22, California Code of Regulations, Division 4.5; Environmental Health Standards for the Management of Hazardous Waste
3. California Executive Order D-62-02 regarding disposal of decommissioned materials.
4. 10 Code of Federal Regulations (CFR) 20; Standards for Protection Against Radiation, and Transfer and Disposal and Manifests
5. 49 CFR, Subchapter C “Transportation – Hazardous materials Regulations”

6. 40 CFR, Subchapter I "Solid Wastes"
7. 40 CFR Part 260-273 "Hazardous Waste Management System"
7. USNRC Circular 81-07, "Control of Radioactively Contaminated Materials."
8. USNRC IE Information Notice No. 80-22, "Breakdowns in Contamination Control Programs."
9. ANSI N13.2-1969, "USA Standard Guide for Administrative Practices in Radiation Monitoring (A Guide for Management)."
10. RP -102, "Radiological Posting Requirements."
11. RP -104, "Radiological Surveys."
12. RP- 105, "Unrestricted Release Requirements."
13. RP -114, "Control of Radiation Protection Records."

4.0 GENERAL

4.1 Discussion

Radioactive material controls are established to provide positive control of radioactive material, prevent inadvertent release of radioactive material to uncontrolled areas, ensure personnel are not unknowingly exposed to radiation from lost or misplaced radioactive material, and to minimize the amount of radioactive waste material generated during PESI activities.

4.2 Definitions

Aggregate Material: Items or materials that by their physical nature do not lend themselves to being effectively surveyed using portable instrumentation and require bulk or composite survey techniques or representative sampling and analysis.

Conditional Release of Material: Items or materials that do not meet unconditional release criteria and that are released under the control of Radiation Protection personnel.

Contamination Area (CA): Means any area with loose surface contamination values in excess of the applicable values specified in RP-104 Acceptable Surface Contamination Levels that is accessible to personnel, or any additional area specified by the RSO. The Contamination Area posting is defined as more restrictive than Radioactive Material Areas, hence all Contamination Area postings are considered to be Radioactive Material postings.

Minimum Detectable Activity (MDA): The smallest amount or concentration of radioactive material in a sample that will yield a net count, above system background, that will be detected with 95% probability with only 5% probability of falsely concluding that a blank observation represents a "real" signal. MDA depends upon the type of instrument, the counting geometry, and the radionuclide to be detected. MDA has the same meaning as Lower Limit of Detection (LLD). (ANSI N13.3, 1989).

Radioactive Material: Material activated or contaminated by the operation or remediation of the site and by-product material procured and used to support the operation or remediation.

Radioactive Material Area: Any area or room where quantities of radioactive materials in excess of ten times the 10 CFR 20 Appendix C quantities are used or stored, or any area designated a RMA by the RSO which does not exceed the site Contamination Area criteria.

Restricted Area: An area to which access is limited to protect individuals against undue risks from exposure to radiation, radioactive materials, and chemical contaminants. All posted radiological or chemical areas are Restricted Areas.

Unconditional Release of Material: Release of equipment or material to the general public. The equipment and / or material are deemed to meet site release criteria for both total and removable contamination.

5.0 RESPONSIBILITIES

5.1 Radiation Safety Officer (RSO)

The RSO is responsible for:

- Ensuring adequate staffing, facilities and equipment are available to perform the radioactive material control functions assigned to Radiation Protection personnel.
- Investigating and initiating corrective actions for the improper handling of radioactive material.
- Approving purchase or acquisition of radioactive sources.
- Ensuring a source inventory and leak testing program is established.
- Authorizing the establishment of radioactive material and sealed source storage locations.
- Packaging and transferring radioactive material to appropriate authorities.
- Administering receipt / release survey programs of radioactive material.
- Administering radioactive source inventory and leak testing.
- Ensuring correct posting of radiological area.
- Reviewing results of sample analysis and survey data as required to determine acceptability for release of items.
- Ensuring packages for transport and disposal meet applicable regulations for integrity and dose limits.

5.2 Certified Waste Shipper

The certified (as required by 49 CFR 172, Subpart H) waste shipper is responsible for:

- Identifying proper packaging and posting requirements for all offsite transport of radioactive and/or mixed wastes.
- Reviewing results of conveyance package radiation surveys and performing inspections of conveyance packages prior to approving packages to leave a site.
- Maintaining records of all waste shipments.
- Assisting the RSO in proper characterization, classification and sampling of any potentially radioactive or mixed waste
- Selecting the treatment, storage and disposal facility (TSDF) to be used for processing, treatment, and/or disposal of radioactive or mixed waste
- Preparing profiles and shipping paperwork for disposal of radioactive or mixed wastes generated
- Directing and performing inspections, marking, labeling and placarding of radioactive or mixed waste prior to shipment
- Selecting the proper packages to use for radioactive or mixed waste
- Maintaining an inventory of radioactive and mixed waste onsite and shipped off the project.
- Ensuring periodic inspections as required by regulation are performed and documented

5.3 Radiation Protection Technicians (RPTs)

The RPT is responsible for:

- Performing and documenting radiation and contamination surveys, inspections and leak tests.
- Posting, securing, and controlling radioactive material and source storage areas.
- Safely opening packages of radioactive material.
- Identifying radioactive material.
- Releasing material in accordance with this and implementing procedures.
- Notifying the RSO or designee on arrival of radioactive material.
- Performing pre-transportation surveys of radioactive materials packaging and conveyance vehicles.

5.4 Project Personnel

Project personnel are responsible for:

- Adhering to all policies, procedures and other instructions, verbal and written, regarding control and minimization of radioactive material and contaminated material.
- Reporting any concerns about the control and minimization of radioactive material and contaminated material to supervision.
- Maintaining good housekeeping at work sites and assisting in preventing the build-up and spread of contamination.
- Obtaining RSO authorization prior to accepting receipt of radioactive material at the project. This includes, but is not limited to items such as sealed sources, liquid standards, and contaminated equipment from other sites, and waste generated outside normal project remediation activities. This is to ensure that required receipt surveys are scheduled, appropriate ALARA considerations are implemented, and that the source term is evaluated for possible effects to the project waste stream criteria.
- Complying with direction from RP personnel regarding the proper methods for receipt, handling, decontamination, packaging, storage, transport and disposal of radioactive material.

6.0 PREREQUISITES

None

7.0 PRECAUTIONS AND LIMITATIONS

Packages of radioactive material or sources shall NOT be opened until the required receipt survey is performed by RP personnel.

Packages of radioactive waste shall not leave a site until approval to do so is granted by the Certified Waste Shipper.

8.0 RECORDS

- Receipt radiological surveys
- Radiological release surveys
- Radiological transportation surveys
- Source Inventory which includes Leak Test Results
- Transportation records including manifests, transportation checklists, and a transportation log

Records generated shall be transmitted to Project Document Control for filing according to procedure RPP-114.

9.0 PROCEDURE

9.1 Receipt of Radioactive Material

1. Obtain RSO authorization prior to accepting receipt of radioactive material at the project.
   - Radioactive materials which may be received include, but are not limited to, items such as sealed sources, liquid standards, contaminated equipment from other sites, waste generated outside normal project remediation activities and shipments of radioactive materials from vicinity properties to the PESI for storage and / or transportation and disposal. This is to ensure that required receipt surveys are scheduled, appropriate ALARA considerations are implemented, and that the source term is evaluated for possible effects to the project waste stream criteria.
   - Refer to 10 CFR 71.4 and Appendix A to 10 CFR 71 for definition and limits for "Type A Quantities" of radioactive materials.
   - The RSO may direct receipt surveys to be performed on any incoming radioactive material shipment.
2. If an expected package exceeds Type A quantities, the package requestor shall make arrangements with RP and the carrier to receive or pick-up the shipment when the carrier makes notification of package availability.
3. RP personnel perform receipt inspections and surveys of incoming radioactive material shipments which exceed a Type A quantity (refer to 10 CFR 71.4 and Appendix A of 10 CFR 71) as follows:
   - The inspection and survey shall be performed within three hours of receipt. If received after normal work hours, the survey is required with three hours from the beginning of the next business day.
   - Don latex gloves, at a minimum, when performing incoming inspections and surveys.
   - Inspect the package for leaks or apparent damage.
   - Ensure the contents match the packing slip or shipping papers.
   - Perform a radiation survey of the package exterior.
   - Perform a removable contamination survey of the package interior and exterior.
4. RP Personnel shall store the package in a secure, radiologically posted area, notify the RSO or designee if any the following conditions are observed during receipt of a radioactive material shipment:
   - Contents do not match packing slip or shipping papers
   - The contents of the package do not contain the isotopes or quantities of material as ordered or expected.
   - Package is leaking or sufficiently damaged to compromise package contents.
   - The receipt survey results exceed any of the following limits:
   - Radiation (mrem/hr) – 200 @ Contact or 10 @ 1 meter from the package
   - Removable Contamination (dpm/100cm2) – 2200 Beta-Gamma, 220 Alpha

9.2 Identification of Radioactive Material

1. Radioactive material exceeding limits specified in 10 CFR 20, Appendix C shall be identified and labeled by Radiation Protection personnel:
   - On receipt of packages containing radioactive material or sources.
   - During removal of items or material from contaminated systems or areas, or from radioactive materials areas.
   - In the course of performing area and job specific surveys.
   - In the course of surveying items for release.
2. Items that meet or exceed the contamination limits established in the PESI RPP should be labeled radioactive material.
3. Use the following guidance, as a minimum, when labeling radioactive material:
   - Labels shall only be placed or removed by Radiation Protection personnel.
   - Unique features (e.g., yellow plastic bags, yellow and magenta tags, purple paint, etc.) should be used to clearly identify the physical and radiological parameters of the material.
   - Labeling shall state "CAUTION - RADIOACTIVE MATERIAL."
4. Exceptions to labeling requirements for radioactive material are as follows:
   - The item or material is under the direct control of personnel who are aware of the contents and the associated radiological hazards.
   - The material is radiation protection equipment (e.g., respirators, instruments. etc.).
   - The material consists of radiological samples being analyzed or sampling equipment controlled by Radiation Protection personnel.
   - The material is packaged and labeled in accordance with DOT regulations while awaiting transport.
   - The material is contained in permanently installed equipment and / or potentially contaminated systems.
   - The material consists of permanently installed equipment or components, including check sources installed in radiation monitoring equipment, which have manufacturer supplied check source labels affixed. Radiation level posting requirements shall remain applicable.
   - The material consists of laundered protective clothing:
     a. In controlled use, inside the Restricted Area; or
     b. Stored in designated laundry containers.
   - The material consists of check sources or sealed sources and source storage containers identified as radioactive material with identifiable labels affixed to the source.

- The material is stored or in-use in a posted Contamination Area or Airborne Radioactivity Area. All items in these areas are considered potentially radioactive/contaminated until properly dispositioned by RP personnel.
- The material consists of contaminated items (e.g., hand tools) impractical to label, that are marked with magenta paint.

5. Project personnel should notify Radiation Protection of any items or containers with lost or damaged radioactive material labels.
6. Material requiring labeling as radioactive material which is found uncontrolled and outside a Restricted Area shall be brought to the immediate attention of RP Personnel.

9.3 Storage of Radioactive Material

1. Radioactive Material Storage Areas shall be posted in accordance with RP -102, "Radiological Posting Requirements."
2. Radiation Protection personnel should consider the following when specifying radiological requirements for Radioactive Material Storage Areas:
    - Changes to radiation levels in an area as a result of material storage.
    - External environmental conditions are such that significant container degradation does not occur during storage.
    - Material is adequately packaged and controlled to minimize the potential for loss of radioactive material control
3. Unsealed radioactive materials e.g. soil, debris, liquids will be posted and controlled in accordance with RP-102, Radiological Posting Requirements.
4. Soil, debris, and materials will be staged in appropriate containers/bags or covered with tarps as necessary to prevent migration outside of radiological boundaries.
5. Liquids will be stored in appropriate containers (e.g. drums, totes, etc.)
6. All storage containers will be labeled with pertinent information including description and radiological data.
7. PPE requirements for handling radioactive materials are established in the applicable RWP and procedure RP-132, *Selection and Use of Radiological PPE.*

9.4 Special Considerations for Control of Accountable Radioactive Sources

1. The RSO, or designee shall serve as the Source Custodian and shall be responsible for the following:
    - Ensuring that all accountable radioactive sources are stored in their designated storage location when not in use.
    - Maintaining a source inventory that includes accountable source identification, isotopic content, activity, assay date, designated storage location, and date and results of most recent semi-annual leak test.

2. Any individual planning to procure a radioactive source for the project shall request approval from the RSO in writing. This request shall include a justification for bringing additional sources onto the project and shall include all necessary source information to update the source inventory.

3. Licensed sources under the control of a licensee (e.g., radiography sources, soil density gauges, etc.) are not maintained in the project accountable source inventory. Project personnel requesting such vendor services shall ensure that the RSO receives evidence of the following prior to source mobilization to the project:

   - Source license including isotope and source activity
   - Semi-annual leak testing performed by the licensee

4. Source Custodian, or designee shall ensure that a leak test is performed and documented for any accountable source in inventory under any the following conditions:

   - Upon source receipt in inventory
   - Semi-annually
   - Prior to transfer to a new permanent storage location
   - Prior to disposal
   - If source integrity is compromised

5. A source leak test consists of a physical source inventory, a visual inspection for source integrity and a contamination survey capable of detecting the presence of 0.005 microcuries (200 Bq) of removable radioactivity.

6. If direct contact with the source is impractical (i.e., inaccessible, unsafe from an ALARA standpoint, or could potentially compromise source integrity) the source container or storage location may be surveyed as representative of the leak test.

7. All accountable sealed radioactive sources or their individual storage containers shall bear a durable label or tag which includes the following minimum information:

   - Source Identification
   - Radionuclide(s)
   - Source Activity
   - Assay Date
   - Source Custodian Name and Contact Number

8. The RSO shall establish designated locations for the storage of accountable radioactive sources using the following guidance:

   - Sources should be stored in a lockable location
   - Sources should be stored to minimize exposure to fire or combustible materials
   - Sources should be stored in such a manner to minimize radiation exposure to personnel routinely present in the area.

9.5 Movement of Radioactive Material

1. Radioactive material or contaminated material shall be properly contained before moving to minimize radiation levels and prevent spread of contamination.
2. Obtain direction from the Project Transportation Specialist and / or the RSO prior to transporting radioactive materials across public highways or railroads regulated by the Department of Transportation. Transport shall be performed in accordance with this procedure and all applicable local, state, and federal regulations.

9.6 Control of Tools, Equipment and Material

1. All items to be released from radiological controls shall be surveyed by RP personnel.
2 The RSO may authorize the establishment of "Hot Tool" storage areas for reusable contaminated tools, components, equipment and material. If labeling of these items (e.g., hand tools) is impractical, magenta paint may be used to identify the item as radioactive material.
3. Project Management should ensure that adequate supplies of clean and "hot" tools are available project personnel. This maximizes worker effectiveness in radiological areas, minimizes survey and decontamination efforts, and reduces radioactive waste generated.
4. Radioactive waste receptacles will be established and maintained for the disposal of items.

9.7 Release of Items from Radioactive Material Controls

1. RP personnel shall perform surveys to release items from radioactive material controls, with the following exception:
   - Hand-carried items (e.g., pens, paper, flashlights, logbooks, clipboards, safety glasses, dosimetry, badges, etc.) under a single individual's control and that are not expected to have come into contact with potentially contaminated surfaces may be monitored by that individual during the personnel frisking process.
2. RP personnel will survey items designated for unrestricted release according to RPP-105, "Unrestricted Release of Equipment."
3. RP personnel shall ensure the labeling is appropriate and direct Project personnel as how to best disposition the item (i.e., decontamination, packaging, storage, or disposal as radioactive waste) if an item is contaminated and cannot be released for unrestricted use.
4. RP personnel shall ensure that any labeling or marking identifying the item as radioactive material is removed or thoroughly defaced if the release survey indicates that the item may be released for unrestricted use.

9.8 Transportation and Disposal of Radioactive Waste

1. Characterization sampling and analysis of waste for radioactive and hazardous constituents shall be performed to ensure waste meets the selected waste facility's Waste Acceptance Criteria.
2. Waste which is considered "decommissioned waste" (waste with residual radioactivity distinguishable from background regardless if it meets alternative requirements for unrestricted release) shall not be disposed of in a Class III California land fill or in a California unclassified waste management unit in accordance with California Executive Order D-62-02.
3. Packaging of waste shall be commensurate with the radionuclide(s) activity and the physical form of the waste in accordance with 49 CFR 178.350 (if applicable).
4. Labeling and placarding of waste packages shall be performed in accordance with 49 CFR 178.350 (if applicable).
5. Radiation surveys shall be performed on waste packaging and/or conveyance vehicles. These surveys shall include dose rates as required by 49 CFR 173 and offsite transportation shall not be permitted if applicable dose limits are exceeded.
6. A transportation inspection shall be performed and documented on the "Transportation Checklist Form" (**Attachment 1**) prior to waste shipments leaving a site.
7. Proper shipping paperwork shall be completed and shall accompany all transports of radioactive waste.
8. Emergency response guidance and contact information shall be provided to all conveyors of radioactive waste (refer to **Attachment 2**).
9. Records of waste disposal shall be maintained sufficient to meet the requirements of CDPH 5314 (to support eventual license termination). Information required includes inventory of waste, dates of transfer, and recipient information. These records should be maintained even if license termination is not the immediate goal of a project.

10.0 ATTACHMENTS

1. Transportation Checklist Form
2. Emergency Response Instructions

Attachment 1

Transportation Checklist Form

TRANSPORT VEHICLE INSPECTION CHECKLIST

Shipment No.	Carrier DOT Hazmat Registration No. / Exp. Date		
Carrier Name:	Tractor No.		Trailer No.
Drivers Name:	State:	License No.	Exp. Date

	ITEM	STATUS Pre Load		STATUS Post Load		CRITERIA
		SAT	UNSAT	SAT	UN SAT	
1	Operator's License					Driver possesses a valid commercial driver's license (with a tank vehicle or hazardous materials endorsement) to operate the vehicle
2	Windshield, Side Glass and Mirrors					No cracked or broken glass that would affect the vision of the driver. Mirror(s) in place and usable
3	Wipers					Wipers operate and are in good condition
4	Horn					Air/electric horn(s) work
5	Suspension					Visually check for loose, broken, or damaged spring leaves, "U" bolts, shackles. Pads, torque arms, and locking pins
6	Brake Lines					Brake lines and connectors do not have cracks, crimps, restrictions, or evidence of damage or audible air leaks
7	Brake Pots, Cams					Brake pots are in good physical condition and mechanical linkages are intact and in good condition
8	Exhaust System					No loose or broken brackets and no evidence of leaks which would affect driving/sleeping compartment
9	Fuel System					No visible damage affecting fuel tank integrity, no visible leaks, no loose or broken mounting brackets, no evidence of damage to vents, and fuel cap is securely in place
10	Structure, Welds					No visible significant cracks in major welds
11	Frame					No cracked, loose, sagging, or broken frame
12	Trailer Floor					No holes or projecting nails. Capable of bearing weight of load and fork truck (if used)
13	Trailer Walls					No holes, severe dents or buckling
14	Trailer End Gate					Can be closed and secured properly
15	Rims					Rims are not bent or cracked and stud nuts are in place
16	Tires					Tires appear properly inflated, tread depths appear greater than minimum (tread depth at least 1/8" on front and 1/16" on all others) and show no evidence of cuts or damage affecting the ply cord
17	Hubs					No visible oil leakage from seals
18	Head Lights					Both low beams working
19	Running Lights					All affixed running lights operable
20	Turn Signals					Front and back working
21	Brake Lights					Must work on tractor and trailer
22	Liner					Insure liner is properly installed
23	Cleanliness					No amount of material from the site on external surfaces of the conveyance.

PRE-LOAD INSPECTION	**(Printed Name, below)**	**(Signature, below)**
INSPECTION DATE:		
POST-LOAD INSPECTION	**(Printed Name, below)**	**(Signature, below)**
INSPECTION DATE:		
Comments:		
REVIEWED BY:	**(Printed Name, below)**	**(Signature, below)**
REVIEW DATE:		

Attachment 2

Emergency Response Instructions

EMERGENCY RESPONSE INSTRUCTIONS

Manifest No.: ______________________

EMERGENCY PHONE NUMBER:

MATERIAL DESCRIPTION:

IMMEDIATE ACTIONS:

RENDER FIRST AID TO INJURED PERSONS

SECURE THE IMMEDIATE AREA

REPORT THE EMERGENCY

FIRST AID:

Use First Aid according to the nature of the injury
Do not delay care and transport of a seriously injured person
Advise medical personnel that injured persons who may have contacted spilled material may be contaminated with low level radioactive material

SECURE THE IMMEDIATE AREA:

Keep unnecessary people at least 160 feet away in all directions and upwind of shipment
Fight small fires with portable extinguisher, *if safe to do so*
Isolate the area and deny entry to unnecessary personnel

REPORT THE EMERGENCY:

Contact the applicable Emergency Phone Number listed at the top of this page.